Appendix A.
Federal Clean Energy Programs

As states pursue their clean energy policies and programs, they can obtain assistance from a variety of federal programs, as described below.

Cross-Cutting Programs

Cross-cutting federal programs support planning, program development, and initiatives for both energy efficiency and clean energy supply measures. The U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) offer a variety of cross-cutting programs, described below.

Clean Energy-Environment State Partnership Program

This EPA voluntary partnership program is designed to help states review and adopt policies and programs that effectively integrate clean energy into a low-cost, clean, reliable energy system for the state. Clean energy includes energy efficiency, clean distributed generation, and renewable energy. As part of the partnership, EPA works with national organizations to support the state partners, highlight accomplishments, and disseminate lessons learned and best practices. National partners include the National Association of State Energy Officials (NASEO), the National Association of Regulatory Utility Commissioners (NARUC), the State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO), and the National Conference of State Legislatures (NCSL).

States participating in the Clean Energy-Environment State Partnership Program can use the *Guide to Action* to develop a *Clean Energy-Environment Action Plan* to help identify and implement existing and new energy policies and programs to increase the use of clean energy.

Web site:
http://www.epa.gov/cleanenergy/stateandlocal/partnership.htm

Energy Efficiency and Renewable Energy Projects

The EPA-State Energy Efficiency and Renewable Energy Projects are a joint initiative among EPA, NARUC, and individual state utility commissions. These projects are designed to explore utility regulatory and market-based approaches that deliver significant energy cost savings and other benefits through greater use of energy efficiency, renewable energy, and clean distributed generation. These approaches may include, for example, rate design, resource planning, transmission and distribution planning, and requirements for clean distributed generation (DG).

Web site:
http://epa.gov/cleanenergy/pdf/eere_factsheet.pdf

Federal Energy Management Program (FEMP)

Administered by DOE's Office of Energy Efficiency and Renewable Energy, FEMP promotes energy efficiency and distributed and renewable energy by reducing the operating costs and environmental impacts associated with federal facilities. FEMP advances energy efficiency and water conservation, promotes the use of distributed and renewable energy, and improves utility management decisions at federal facilities. FEMP also offers online information resources, an annual training conference, and workshops to state and local government energy managers. The FEMP Web site provides a compendium of energy efficiency purchasing recommendations, interactive energy cost calculators, and other resources to help purchase energy-efficient products.

Web site:
http://www.eere.energy.gov/femp/

The Industrial Technologies Program

DOE's Office of Energy Efficiency and Renewable Energy supports energy efficiency and renewable energy through the Industrial Technologies Program, which seeks to reduce the energy intensity of the U.S. industrial sector. Through the Best Practices subprogram, DOE works with industry to identify plant-wide opportunities for energy savings and process efficiency.

Web site:
http://www.eere.energy.gov/industry/

State Activities and Partnerships

DOE's Office of Energy Efficiency and Renewable Energy provides technical assistance to state and local jurisdictions that enables them to adopt renewable energy and energy efficiency technologies. The program also offers training and information on funding opportunities and state activities.

Web site:
http://www.eere.energy.gov/states/

The State Energy Program

DOE's Office of Energy Efficiency and Renewable Energy provides grants to states to design and implement their own renewable energy and energy efficiency programs. Because the state energy offices administer their own projects, the technologies and applications that they develop vary widely depending on the state's energy priorities and available renewable resources. This facilitates rapid and inventive deployment of supporting technologies that are environmentally friendly and innovative. These activities cover a wide range of possible projects across all energy-use sectors (i.e., the building, industrial, utility, and transportation sectors). Under the State Energy Program, states have modernized more than 69,000 buildings and completed more than 8,000 energy projects.

Web site:
http://www.eere.energy.gov/state_energy_program/

The Technical Assistance Program (TAP)

The DOE TAP provides state and local officials with quick, short-term access to experts at DOE's national laboratories for assistance with cross-cutting renewable energy and energy efficiency policies and programs that are not currently covered by an existing DOE program. Individualized assistance is available in five eligible areas: (1) system benefit charges or other ratepayer-funded utility efficiency and renewable programs, (2) renewable or efficiency portfolio standards, (3) use of clean energy technologies to help states and localities address air emissions, (4) use of renewable energy on state and local public lands, and (5) disaster relief, mitigation, and planning. Currently, technical assistance is available from three participating laboratories: the National Renewable Energy Laboratory (NREL), the Oak Ridge National Laboratory (ORNL), and the Lawrence Berkeley National Laboratory (LBNL).

Web site:
http://www.eere.energy.gov/wip/informationresources/Tap.html

Energy Efficiency Programs

EPA, DOE, and the U.S. Department of Housing and Urban Development (HUD) administer a variety of programs that provide resources, technical assistance, and research findings on energy efficiency technology and applications.

ENERGY STAR

ENERGY STAR is a voluntary, public-private partnership designed to reduce energy use and related greenhouse gas emissions, where cost-effective. The program delivers significant energy savings, on the order of 135 billion kWh in 2004 or 4% of the nation's total 2004 electricity needs. ENERGY STAR involves an extensive network of partners, including state energy offices, product manufacturers, retailers, home builders, energy service companies, private businesses, and public sector organizations. ENERGY STAR programs employ strategies designed to overcome market barriers and provide information and tools that alter decisionmaking for the long term. Many of the strategies help reduce transaction costs and lower investment risks, making efficiency projects more attractive. Through ENERGY STAR, EPA and DOE invest in energy efficiency efforts that states and utilities can leverage as part of their energy efficiency programs. Key program areas include:

National ENERGY STAR Education Campaign

Since 1997, EPA has operated broad-based public campaigns to educate consumers about the link between energy use and air emissions and to raise awareness about how products and services carrying the ENERGY STAR label can protect the environment while saving them money. Local energy efficiency programs can take advantage of national efforts by incorporating relevant messages or leveraging the campaign via marketing, customer education, and outreach.

Qualifying Products

A government-backed energy efficiency designation—the ENERGY STAR label—is on products in more than 40 categories for the home and business, including heating and cooling, lighting, office equipment, appliances, windows, home electronics, and commercial food service equipment. Each year, EPA and DOE spearhead product-specific national campaigns, enable information exchange on well-developed utility-retailer program models, hold national partner meetings that facilitate networking and collaboration, and provide an array of online resources. Because of ENERGY STAR's well-developed program models and infrastructure, the promotion of ENERGY STAR qualifying products offers a good starting point for new energy efficiency programs.

Existing Homes

ENERGY STAR provides opportunities for obtaining substantial energy savings from improving the heating and cooling systems and envelopes in existing homes; this represents a savings potential that cannot be obtained solely through use of energy-efficient products. The ENERGY STAR program offers specifications for home improvement services such as Home Performance with ENERGY STAR, which emphasizes home diagnostics and evaluation, improvements made by trained technicians and building professionals, sales training, and strong quality assurance. In addition, ENERGY STAR offers systems solutions for home sealing, heating and cooling system best practices, and duct sealing and provides valuable online consumer tools including the Home Energy Yardstick.

New Homes

ENERGY STAR qualifying homes are substantially more efficient than homes built to a model energy code. EPA provides a number of tools to engage home builders in constructing ENERGY STAR qualifying homes, including builder recruitment and sales materials and consumer education and outreach. Many energy efficiency programs promote ENERGY STAR qualifying homes by providing builder training, consumer education, and direct verification of home performance or incentives to offset the cost of verification. Other incentives might include co-op marketing incentives and rebates for qualifying homes.

Commercial Building Performance

The energy efficiency of commercial buildings can be dramatically affected by design, sizing, installation, controls, and operations and maintenance. To better ensure that measures such as lighting, controls, high-efficiency air conditioning, motors, and variable speed drives will deliver expected energy savings, EPA designed an Energy Performance Rating System to measure the energy performance at the whole-building level. Buildings that score low (on a scale of 1 to 100) are typically good candidates for cost-effective improvements, and buildings that score high are eligible for the ENERGY STAR label. ENERGY STAR-labeled buildings use 40% less energy and cost 40% less to operate than average buildings. EPA also works with building owners to encourage them to adopt organization-wide energy management approaches. EPA is working with utility programs throughout the country to integrate these strategies into commercial programs to enhance program uptake and effectiveness.

Industrial Energy Efficiency

ENERGY STAR promotes and encourages superior corporate energy management through the provision of tools and resources specific to the needs of manufacturers. Unique resources offered by ENERGY STAR for manufacturers include opportunities to participate in sector-focused activities, networking opportunities with other industrial energy managers in the broad partnership, the industrial Web site, energy program communication resources, and assistance in developing or improving a corporate energy performance program. Each year, the industrial partnership identifies certain manufacturing sectors to engage in focus activities. These activities include an in-depth study and assessment of energy efficiency opportunities within the sector; production of an energy performance indicator for plants in the sector; and sector-specific energy working groups, including focus meetings aimed at improving corporate energy performance. The partnership currently includes more than 450 participating industrial companies of varying sizes and coordinates focus initiatives with seven industrial sectors.

Web site:
http://www.energystar.gov

Building America

Building America is a DOE/industry partnership that develops energy solutions for new and existing homes. Building America combines the knowledge and resources of building industry leaders with DOE's technical capabilities. The ultimate goal of the program is to achieve a 70% reduction in total home energy use, enabling the balance of energy requirements to be easily met by a solar electric system. As of October 2003, the Building America approach has been used in the design of more than 20,000 houses in 34 states. This accomplishment is a result of the efforts of more than 250 builders implementing projects in many cities across the United States.

Web site:
http://www.eere.energy.gov/buildings/building_america/

Building Technologies Program

DOE's Building Technologies Program helps improve building energy efficiency through the use of innovative new technologies and better building practices. The program includes research and regulatory activities. Research activities advance the next generation of energy-efficient components, equipment, and materials, including a whole-building approach that optimizes building performance and savings. Regulatory activities include efforts to work with state and local regulatory groups and other interested parties to improve building codes, appliance and equipment standards, and guidelines for efficient energy use, and to assist states in updating, implementing, and enforcing their building energy codes.

Web site:
http://www.eere.energy.gov/buildings/

Weatherization Assistance Program (WAP)

Under WAP, DOE works with states and local governments to help low-income families reduce their energy bills by making their homes more energy efficient. Through WAP, weatherization service providers install energy efficiency measures in the homes of qualifying homeowners free of charge. During the last 27 years, WAP has provided weatherization services to more than 5.3 million low-income families. Weatherized households have average energy savings of $224 per year, which amounted to a cost savings of more than $1 billion for all homes served during winter 2000.

Web site:
http://www.eere.energy.gov/weatherization/

The Partnership for Advancing Technology in Housing (PATH)

PATH is a public-private initiative dedicated to accelerating the development and use of technologies that radically improve the quality, durability, energy efficiency, environmental performance, and affordability of America's housing. PATH is a collaborative partnership managed by HUD that spurs change in housing industry design and construction.

Web site:
http://www.hud.gov/offices/cpd/energyenviron/energy/initiatives/index.cfm#path

Partnerships for Home Energy Efficiency (PHEE)

PHEE is a multi-agency (i.e., DOE, EPA, and HUD) program to help households reduce their home energy bills by increasing awareness of ENERGY STAR products, developing new energy efficiency services for homeowners; delivering energy efficiency savings to subsidized and low-income housing; and investing in innovative research in building science technologies, practices, and policies. PHEE incorporates HUD's PATH Roadmap for Energy Efficiency in Existing Homes, which outlines a series of strategies for boosting the energy-efficient remodeling of existing homes and the HUD Energy Action Plan, which promotes energy efficiency in 5 million housing units that have been assisted, insured, or financed by HUD.

The goal of PHEE is to help households save 10% or more on home energy bills over the next 10 years. The initiative builds on existing policies and programs that involve partnerships with manufacturers, retailers, home contractors and remodelers, utilities, states, financial organizations, educational institutions, and others to leverage the power and creativity of the marketplace. Key efforts include:

- Expanding efforts to promote ENERGY STAR products.
- Promoting energy efficiency in affordable housing.
- Continuing to invest in innovative research in building science technologies, practices, and policies.

Web site:
http://www.energysavers.gov/

Clean Energy Supply Programs

EPA and DOE offer a variety of clean energy supply programs that provide information, technical assistance, and research findings related to renewable energy and clean distributed generation, including combined heat and power.

The Combined Heat and Power (CHP) Partnership

The objective of this program is to reduce the environmental impact of power generation by fostering the use of CHP. Through the CHP Partnership, EPA works closely with energy users, the CHP industry, state and local governments, and other stakeholders to support the development of new projects and promote their energy, environmental, and economic benefits.

Web site:
http://www.epa.gov/chp

The Green Power Partnership

The Green Power Partnership is a voluntary partnership between EPA and organizations interested in buying green power. EPA provides technical assistance and recognition to organizations that pledge to replace a portion of their electricity consumption with green power within a year of joining the partnership.

Web site:
http://www.epa.gov/greenpower/

Buildings Cooling Heating and Power (BCHP) Initiative

The BCHP Initiative is part of the broader building technology efforts of DOE's Office of Energy Efficiency and Renewable Energy. The initiative addresses onsite fuel technologies that make it possible to combine power generation and heating, ventilation, and air conditioning (HVAC) system optimization and integration with other innovative building technologies related to thermal utilization, cooling, and dehumidification.

Web sites:
http://www.eere.energy.gov/de/pdfs/bchp_roadmap.pdf
(describes the BCHP Initiative)

http://www.chpcentermw.org/
(information on the Midwest CHP Application Center [MAC], one of several centers established by DOE to facilitate deployment of CHP technologies through the provision of application assistance, technology information, and educational support.)

Distributed Energy Program

DOE's Distributed Energy Program supports research and development with the goal of lowering costs for distributed energy technologies, reducing emissions, and improving the reliability and performance of these technologies. Program activities focus on two technology areas: distributed energy technologies (including gas-fired reciprocating engines, industrial gas turbines, and microturbines) and integrated energy systems such as CHP.

Web site:
http://www.eere.doe.gov/de/

Geothermal Technologies Program

DOE administers the Geothermal Technologies Program in partnership with industry to help promote geothermal energy as an economically competitive contributor to the U.S. energy supply. It seeks to develop hydrothermal, direct use, and shallow depth area technologies to achieve long-term viability. This program produces many benefits, such as economic competitiveness, environmental improvement, and sustainability of resources.

Web sites:
http://www.eere.energy.gov/geothermal/

http://www.eere.energy.gov/RE/geothermal.html

Hydrogen, Fuel Cells, and Infrastructure Technologies Program

DOE is working with its partners to accelerate the development and successful market introduction of hydrogen, fuel cell, and infrastructure technologies. DOE's Web site provides information on the agency's research, development, and applications in these areas.

Web sites:
http://www.eere.energy.gov/hydrogenandfuelcells/

http://www.eere.energy.gov/RE/hydrogen.html

Million Solar Roofs

DOE is supporting the Million Solar Roofs initiative through national, state, and local partnerships to install solar energy systems (photovoltaic and solar thermal systems) in one million U.S. buildings by 2010. While this program does not direct state actions or provide funding for solar energy systems, it does facilitate collaboration between the federal government, key national businesses, and organizations. This cooperation allows partners and stakeholders to focus on building a strong market for solar energy applications in buildings.

Web site:
http://www.millionsolarroofs.org/

Solar Energy Technologies Program

Through its Solar Energy Technologies Program, DOE works with other federal, state, and local agencies; national laboratories; universities; industry; and professional organizations to research, develop, and deploy cost-effective technologies to expand the use of solar energy throughout the United States and the world. DOE provides information on solar technologies and applications including concentrating solar power, photovoltaics, solar heating, and solar lighting.

Web sites:
http://www.eere.energy.gov/solar/

http://www.eere.energy.gov/RE/solar.html

Wind and Hydropower Technologies Program

DOE's Office of Energy Efficiency and Renewable Energy is working to improve wind energy technology so it can generate competitive electricity in areas with lower wind resources and to develop new, cost-effective, advanced hydropower technologies that will have enhanced environmental performance and greater energy efficiencies. DOE provides information on its Web site on both wind and hydropower energy resources, applications, and technologies.

Web sites:
http://eere.energy.gov/windandhydro

http://www.eere.energy.gov/RE/wind.html

http://www.eere.energy.gov/RE/hydropower.html

Appendix B. Energy Efficiency Program Resources

This appendix provides information on key steps to bring energy efficiency programs to market and provide oversight for investments once these programs have been established. It describes how states can build a portfolio of energy efficiency investments and then monitor and evaluate those investments. The intended audience for this material includes state public utility commissions (PUCs), other agencies that oversee energy efficiency programs, program administrators such as utility program managers and third parties, and other organizations involved in implementing and evaluating energy efficiency programs.

Mechanisms for securing funding for energy efficiency investments are not included in this section. These issues are covered in detail elsewhere in the *Guide to Action*, including Section 3.1, *Lead by Example*, Section 3.4, *Funding and Incentives*, Section 4.1, *Energy Efficiency Portfolio Standards*, Section 4.2, *Public Benefits Funds for Energy Efficiency*, and Section 6.1, *Portfolio Management Strategies*.

Building a Portfolio of Energy Efficiency Investments

States are developing energy efficiency investment portfolios as part of their larger energy strategy. This allows states to position themselves for both short- and long-term energy needs in a way that is cost-effective, serves diverse constituencies, minimizes energy supply and environmental risks, and can help reduce price volatility. Determining the appropriate mix of energy efficiency measures in an overall energy efficiency program portfolio typically involves a series of interrelated activities:

- Assessing the potential for energy efficiency to meet resource needs and inform funding decisions.
- Involving stakeholders in planning.
- Assessing multiple system and customer needs.
- Considering transmission and distribution (T&D) needs.
- Allocating energy efficiency investments within a portfolio.
- Screening for cost-effectiveness.
- Developing program plans.

State and regional approaches for undertaking these activities are addressed in this section.

Assessing Energy Efficiency Potential

As a fundamental step in determining an appropriate level of funding for energy efficiency measures, states or regions typically conduct studies of the potential for increased investments to reduce energy use within a specified time frame. The primary goal of these analyses is to determine the availability of energy efficiency as a resource option (irrespective of the policy or funding mechanism for achieving that potential). In addition to identifying an appropriate level of efficiency investment for a state, potential studies provide valuable data that can be used in the program planning and design stage. States can use this information to:

- Make the initial case or justification for undertaking the establishment of energy efficiency policies and programs.
- Characterize the current and future potential for energy efficiency to identify the most important market sectors and end uses for tapping the efficiency resource potential.
- Obtain detailed information about specific measures and the broader efficiency market to aid in technology screening and program design.

Potential studies typically calculate the following types of potential:

- *Technical potential* assumes the complete penetration of all energy conservation measures that are considered technically feasible from an engineering perspective.
- *Economic potential* refers to the subset of technical potential that is cost-effective when compared to supply-side alternatives.
- *Maximum achievable potential* is the economic potential that could be achieved over time under the most aggressive program scenario.
- *Program potential* refers to energy saved as a result of a specific program's funding level and incentives. These savings are above and beyond what would occur naturally in the absence of any market interventions.
- *Naturally occurring potential* refers to energy saved as a result of normal market forces, that is, in the absence of any utility or governmental intervention (Rufo and Coito 2002, Optimal Energy 2005).

Efficiency potential studies are typically conducted at the state or regional level. In most cases, efficiency is assessed across residential, commercial, and industrial customer classes. These analyses usually employ quantitative analysis of potential combined with expert judgment on the feasibility and likely performance of the measures being assessed. Estimates of achievable potential are often based on experiences from similar programs around the country.

The results of energy efficiency potential studies can identify untapped opportunities for savings and encourage policy development and program implementation. Recent studies identify economic potential in the ranges of 13% to 27% for electricity and 21% to 35% for gas. Achievable potential—the realistic estimate of what can actually be achieved from programs—ranges between 10% to 33% for electricity and 8% to 10% for gas (Nadel et al. 2004). For example:

- The Southwest Energy Efficiency Project (SWEEP) found that investing about $9 billion (in 2000 dollars) in efficiency measures from 2003 to 2020 would reap total economic benefits for the Southwest region of approximately $37 billion. The resulting benefit-cost ratio is about 4.2, with energy efficiency measures costing, on average, $0.02 per kilowatt-hour (kWh) saved (SWEEP 2002).
- In Connecticut, a 2004 study uncovered significant energy efficiency potential, with opportunities in all sectors. This study found that capturing the achievable cost-effective potential for energy efficiency would reduce peak demand by 13% (908 megawatt [MW]) and electric energy use by 13% (4,466 gigawatt-hours [GWh]) by 2012. This would result in zero electric load growth from 2003 through 2012 and achieve net benefits of $1.8 billion (Connecticut ECMB 2004).
- New York estimated the potential for a bundled increase in energy efficiency and renewable energy, and found that the combined effects could reduce the state's annual electricity generation requirements by 19,939 GWh in 2012 and by 27,244 GWh in 2022. This represents 12.7% and 16.1% of expected statewide requirements for those years, and is achievable at costs below those of conventional generation (Optimal Energy et al. 2003).

Three Levels of Efficiency Potential Studies

Energy efficiency potential studies can be completed across multiple sectors (i.e., an aggregate study), can provide greater detail within sectors and sub-markets (i.e., a targeted study), or can develop a robust set of data for a full range of individual efficiency measures (i.e., a detailed study).

The cost of an aggregate study can range from a low of about $20,000 to more than $50,000 depending on the size of the state or region and whether all sectors are studied.

Targeted studies typically cost between $50,000 and $100,000 depending on scope and detail. These studies evaluate intra-sectoral trends and characterize end-uses such as motors, residential HVAC, and commercial lighting.

Detailed studies typically include benefit and cost data for individual measures and can range from $50,000 for a study that examines a limited number of sectors to well over $250,000 for a detailed multi-sector analysis that includes detail program design recommendations (Prindle and Elliot 2006).

- A study for California found that, despite a long track record of delivering energy efficiency programs, energy efficiency resources can play a significantly expanded role in the state's electricity resource mix over the next decade. With implementation of all cost-effective program potential, the study estimates that growth in peak demand could be cut in half. This "advanced efficiency" scenario would result in peak savings of 5,900 MW, energy savings in excess of $20 billion, and net benefits of $11.9 billion (Rufo and Coito 2002).

After identifying the achievable level of energy efficiency, this resource can be compared with the cost of supply-side options enabling states to select a combination of measures that result in the lowest overall costs and largest benefits to utilities and customers. In practice, states often accomplish this by comparing the "avoided cost" of generation, transmission, and distribution with the cost of implementing energy efficiency. States are finding that accurate data on T&D are particularly important when evaluating efficiency in the context of peak-oriented end uses such as air conditioning. In these cases, the avoided cost of physically moving electricity may equal or exceed the value of the energy savings themselves. Another increasingly important consideration for some states is the avoided environmental costs of energy efficiency, including air emission reductions and water savings (Biewald et al. 2003).

Involving Stakeholders in Planning

There is typically a lag time between the time a policy mandate is established and the program administrator develops and implements energy efficiency programs. Administrators can take advantage of this time period to form an Energy Efficiency Advisory Group (often referred to as a Demand-Side Management [DSM] Advisory Group). Meetings of the advisory group are usually open to all interested stakeholders and commonly engage commission staff, ratepayer advocates, contractors and suppliers, and representatives from all customer classes. The program administrator may use the advisory group to:

- Solicit input on program ideas.
- Solicit input on program design issues.
- Review draft requests for proposals for program implementation assistance.
- Provide input on evaluation plans.
- Review draft market assessments and other evaluation reports.

A key consideration for the stakeholder group is the level of experience of the program administrator and implementer. For example, a state that has been designing and overseeing efficiency programs for two decades may take a very different approach than a state with little experience in the field.

Addressing Customer Needs

All customer classes benefit from well-managed energy efficiency programs,[48] regardless of whether they participate directly. However, those who participate receive both the direct benefit of participation and the indirect benefit derived from system-wide program savings and reliability enhancements. Since all customer classes are typically required to pay into energy efficiency programming, many states have developed programs that provide direct benefits for each of their major customer classes, including:

- Residential homeowners.
- Multifamily tenants.
- Low-income customers.
- Small business owners.
- Commercial and industrial (C&I) customers.[49]

States with multiple utilities may wish to ensure that each service territory receives direct benefits that are roughly proportional to the amount paid into the system by customers within that service territory. However, it is important to address this issue in a way

48 For example, an evaluation of the New York State Energy Research and Development Authority (NYSERDA) program concluded: "Total cost savings for all customers, including non-participating customers [in New York Energy $mart programs] is estimated to be $196 million for Program activities through year-end 2003, increasing to $420 million to $435 million at full implementation" (NYSERDA 2004a).

49 Some states allow large C&I customers to opt out of paying program costs if they secure comparable efficiency through other means. This is sometimes referred to as "industrial self direction."

that does not constrain program design and implementation. For example, in a state with multiple utilities, a best practice for a mass-market lighting and appliance program is to require a consistent statewide program that delivers energy efficient products through existing retailer sales channels. Depending on program design, it may not be practical or cost-effective to prove the specific jurisdiction in which a particular product was installed. Consequently, utilities and their oversight authority sometimes reach advanced agreement that energy savings will accrue to each program administrator in proportion to the results of their program offering (usually a financial incentive to the retailer, manufacturer, or customer).

Another important customer need is to avoid regulatory delay and disruption to energy efficiency services. To minimize risk, states can define in advance the conditions under which program funds can be reallocated, either within a customer class or between customer classes. For example, if a high-performing and well-subscribed residential program runs out of funding and a commercial program is not meeting program targets, states can determine whether funds should: (1) be redistributed between these two customer classes, (2) come from another residential program offering, or (3) be forward-funded from a future program year. Alternately, if the highly successful program is temporarily suspended, states can assess the customer service implications, implications for future program success, and whether the program administrators will be able to re-engage other program participants (e.g., suppliers such as retailers and contractors) in the future.

Considering Transmission and Distribution Needs

State officials and other stakeholders are increasingly considering whether funds should be set aside to use energy efficiency as a "nonwires" solution to eliminate T&D congestion. Such investments have the potential to improve the reliability of the electricity grid as a whole. Two examples of this approach include:

- The Connecticut Energy Efficiency Fund directs a large share of its resources to the transmission-constrained southwest region of the state. One-quarter of all efficiency funding goes to the highly constrained Norwalk-Stamford area, while another quarter is allocated to the remainder of southwest Connecticut. As a result, one-half of the Fund's $60 million is being used to mitigate the state's electricity transmission problem (ECMB 2005).
- In California, the cost-effectiveness evaluation of each energy efficiency program and the overall energy efficiency portfolio uses avoided costs that include the avoided cost of T&D, which reflects locational differences. The California Public Utilities Commission (CPUC) takes these T&D constraints into account during the final integration of all programs into the portfolio plans for each utility (CPUC 2005).

The issue of whether to allow efficiency funds to be used to fund "nonwires" solutions is complicated by rate design mechanisms in areas of the country where there is a regional transmission system and multi-state holding companies. While an in-depth discussion of this issue is beyond the scope of the *Guide to Action*, states are becoming increasingly interested in looking to energy efficiency to alleviate T&D congestion. This issue was explored in a 2003 report sponsored by the New England Demand Response Initiative (NEDRI 2003).

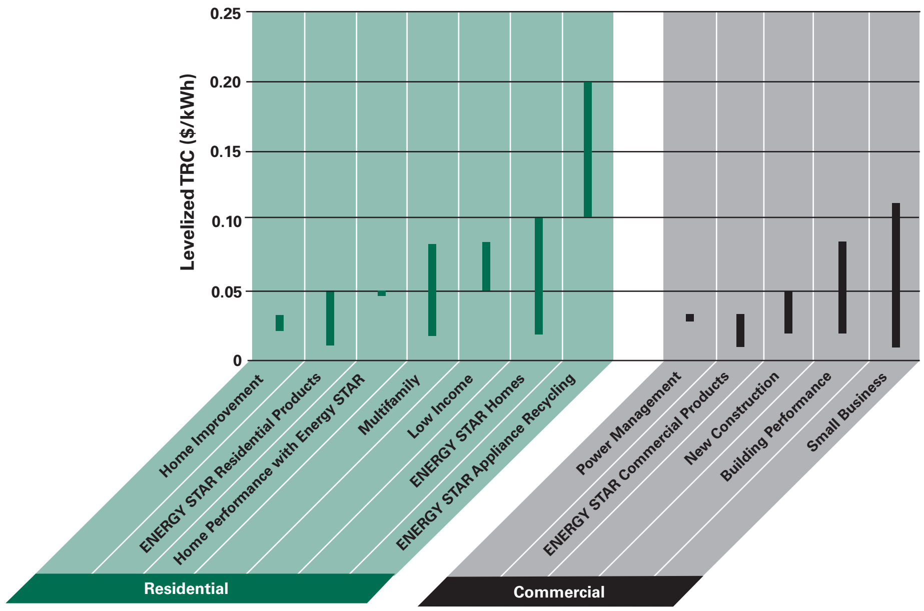
Allocating Efficiency Investments

Once an overall funding level is established, program administrators conduct further screening of individual programs or measures. Program administrators typically balance their efficiency program investment based on the same principles that one would use in evaluating a stock portfolio. For instance, they may ask:

- How reliable is the investment?
- When will it achieve savings?
- How long will those savings last?
- What other investments and/or strategies need to be considered to offset risk?
- Is it wise to include some long-term investments?

At the aggregate portfolio level, many states are able to achieve energy savings at an annual levelized

Figure B.1: Energy Efficiency Program Costs



Sources: EPA estimates based on Efficiency Vermont 2002, SCE 2004, Xcel Energy 2004, Kim 2005, Northwest Power Planning Council 2005.

Total Resource Cost (TRC) of about 0.02 $/kWh to 0.04 $/kWh,[50] although the cost of individual measures or programs can be much higher (see Figure B.1). Nevertheless, including some higher-cost strategies as a part of a broader energy efficiency portfolio may be desirable for a number of reasons; for example, higher costs may be acceptable when savings are more reliable. Certain practices such as verifying proper installation of a home heating and cooling system may add costs to a program, but they increase confidence that the installed measures will actually deliver targeted energy savings and deliver other benefits, such as improving indoor air quality and comfort.

Other factors that can be considered include whether an efficiency measure delivers energy reductions at peak times, reduces water consumption, or offers other nonenergy benefits. States may also invest a portion of their energy efficiency funding in research and development programs that identify and promote emerging technologies, practices, and program models.

Screening for Cost-Effectiveness

Once policies, funding levels and mechanisms, and relative portfolio allocations have been established, organizations charged with overseeing energy efficiency resources usually analyze more in-depth data on cost-effectiveness to further screen programs and measures before approving final program plans.

Many states incorporate cost-effectiveness analysis into the design and evaluation of their programs. This helps ensure the effective use of public funds and can be used to compare program and technology performance with the aim of developing effective future programs. Cost-effectiveness tests commonly used by states are shown in Table B.1.

One frequently used basic economic assessment tool is the TRC Test. This test assesses the net lifetime benefits and costs of a measure or program, accounting for both the utility and program participant perspectives. As with other cost-effectiveness tests, if the benefit-cost ratio is greater than one, it is deemed to be cost-effective. If applied at a portfolio level, individual measures and programs can then

50 The TRC takes into account program administration costs and the full incremental costs of a technology or measure regardless of who pays those costs.

Table B.1: Common Cost-Effectiveness Tests

Type of Test	Description
Total Resource Cost (TRC) Test	Compares the total costs and benefits of a program, including costs and benefits to the utility and the participant and the avoided costs of energy supply.
Societal Test	Similar to the TRC Test, but includes the effects of other societal benefits and costs such as environmental impacts, water savings, and national security.
Program Administrator Test	Assesses benefits and costs from the program administrator's perspective (e.g., benefits of avoided fuel and operating and capacity costs compared to rebates and administrative costs).
Participant Test	Assesses benefits and costs from a participant's perspective (e.g., reductions in customers' bills, incentives paid by the utility, and tax credits received as compared to out-of-pocket expenses such as costs of equipment purchase, operation, and maintenance).
Rate Impact Measure	Assesses the effect of changes in revenues and operating costs caused by a program on customers' bills or rates.

Source: UNEP 1997.

be further screened based on the extent to which benefits exceed costs and on other portfolio considerations mentioned previously in this section.

Sometimes states use a combination of tests to examine the program impacts from different perspectives. In Iowa, for example, the state legislature directed the Iowa Utilities Board to use several cost-effectiveness tests (i.e., the Societal Test, Utility Cost Test, Rate Impact Measure, and Participant Test) in evaluating the overall cost-effectiveness of its energy efficiency plans.

States wishing to consider the non-electric implications for energy use and energy savings may use the Societal Test, which incorporates a broader set of factors than the TRC Test. The Program Administrator and Participant Tests are sometimes used to help design programs and incentive levels, rather than as a primary screen for overall cost-effectiveness. For example, California recently proposed adding the Program Administrator Test as a secondary screening measure to ensure that utilities do not provide excessive financial incentives to program participants.

If using only one test, states are moving away from the Rate Impact Measure (RIM) Test because it does not account for the interactive effect of reduced energy demand from efficiency investments on longer term rates and customer bills. Under the RIM test, any program that increases rates would not pass, even if total bills to customers are reduced. In fact, there are instances where measures that increase energy use pass the RIM Test.

While many utilities and PUCs express program performance in terms of benefit-cost ratios, expressing program costs and benefits in terms of dollars per kilowatt-hour ($/kWh) is also useful because it is easy to relate to the cost of energy. Consumers and legislators can relate this metric to the cost of energy in their own area, while utilities and regulators can compare this value to the avoided costs of energy supply.

The cost-effectiveness tests chosen by a regulatory organization during the initial screening phase are usually used to evaluate and recalculate savings throughout the life cycle of a program or portfolio to ensure that results are consistent with expectations and to assess program impacts. Additional resources on cost-benefit tests are provided in the *Information Resources* section on page B-14.

Developing Program Plans

The program oversight authority typically requires program administrators to submit detailed program plans for approval before beginning program implementation. At a minimum, good program plans include the following information for the overall program and for the individual programs that comprise the overall approach:

- Program descriptions.
- Program goals and objectives.
- Budgets.
- kW and kWh goals including anticipated annual energy savings and lifetime energy savings.

- Benefits and costs.
- Marketing and implementation strategies.
- Major milestones.
- Evaluation plans (including identification of metrics for program success) (EPA 2006).

States can require program administrators to use either a deemed savings or measured savings approach when assessing the potential energy savings of program measures. Deemed savings are the per unit energy savings that are claimed for specific measures; this approach is appropriate for estimating potential savings of common energy efficiency measures. The measured savings approach is more applicable for customized measures and large-scale projects (see box, *Determining Whether to Use "Deemed" or "Measured Savings" Approaches to Quantify Energy Benefits*).

Determining Whether to Use "Deemed" or "Measured Savings" Approaches to Quantify Energy Benefits

Two methods for assessing savings from energy efficiency programs are the *deemed savings* and *measured savings* approaches. Both methods can be used on a prospective basis during the energy efficiency planning phase. This gives states a sense of the savings potential associated with a given portfolio of investments. Some states, particularly those with aggressive timelines for implementing energy efficiency programs, are coming to advanced agreement on which measures in an efficiency portfolio can be estimated using "deemed" savings and which programs or projects will require "measured" savings approaches.

Deemed savings usually apply to the most common energy efficiency measures. Deemed savings values are the per unit energy savings values that can be claimed from installing specific measures. Since they are agreed upon between the program oversight authority and the energy efficiency program administrator, deemed savings can help alleviate some of the guesswork in program planning and design. Deemed savings values are then used as inputs by the program administrator in screening for cost-effectiveness and developing program plans. If a utility receives financial incentives for implementing efficiency programs, deemed savings can also become the basis for incentive claims. Therefore, it is important to consider the suitability of deemed savings approaches for different types of programs and measures and to include requirements for periodic review of deemed savings values in program evaluation, monitoring, and verification activities in advance of policy setting. In general, deemed savings approaches are most reliable for the following types of measures:

- Technologies that typically deliver energy savings independent of human factors such as contractor installation practices or consumer behavior (e.g., plug-in products).
- Technologies that have a clear standard by which to compare efficient and less efficient products (e.g., the Federal National Appliance Energy Conservation Act [NAECA] Standard or ENERGY STAR designation).
- Technologies that have been promoted by other efficiency programs; that have well-established usage patterns, measure life, and performance history; and where usage is not driven by weather.
- Plug-load technologies that are weather sensitive (e.g., room air conditioners and dehumidifiers). Additional analyses can be performed to develop reasonable deemed savings values for technologies installed in each climate zone within a state or service territory.

States that use deemed savings values include New Jersey, Texas, California, and Vermont. Relevant documents and materials from these states can be found in the *Information Resources* section on page B-14.

Measured savings approaches require a high level of rigor and may involve the application of end-use metering, billing regression analysis, or computer simulation. Measured savings approaches are usually used for custom measures and large-scale projects. These approaches add to administrative costs but may provide more accurate savings information. In the planning stage, a utility or other program administrator typically develops savings estimates from the bottom up trying to anticipate the mix of measures that will be involved in a particular project or program. As programs mature over time, utilities usually improve their ability to forecast the measures that will be installed in custom programs. However, because it is difficult to anticipate the interactive effects of specific technologies in complex and variable building systems, it is important to verify measured savings for these types of programs.

Program administrators usually have about three months to develop and submit their program plans. Similarly, oversight authorities typically need about three months to review and approve or suggest modifications to plans. In order to ensure programs are implemented as quickly as possible once approved, program administrators issue requests for proposals during this time period (if they did not do so earlier) and contracts decisions are made contingent upon approval by the oversight authority (Geller 2006).

Evaluating Energy Efficiency Investments

Evaluation is important for sustaining the success of and support for energy efficiency programs and for helping to determine future investment strategies. Unless program overseers can show concrete and robust program results in line with their stated objectives, decisionmakers may not re-authorize the program, the program may become vulnerable to funding shifts or other forms of erosion, and public funds may be poorly spent. State policymakers are promoting evaluation requirements both during program development and after program implementation.

Key elements of state evaluation programs are shown in the box, *Best Practices: Evaluating Energy Efficiency Programs*. Four key aspects of an effective evaluation strategy are addressed below:

- Addressing multiple objectives.
- Managing evaluation activities.
- Measuring energy savings.
- Coordinating with other states and regions.

Addressing Multiple Objectives

Evaluation is used to inform ongoing decisionmaking, improve program delivery, verify energy savings claims, and justify future investment in energy efficiency as a reliable energy resource. Engaging in evaluation during the early stages of program development can save time and money by identifying program inefficiencies and suggesting how program funding can be optimized. It also helps ensure that critical data are not lost.

Best Practices: Evaluating Energy Efficiency Programs

- Evaluate programs regularly, rigorously, and cost-effectively.
- Use methods that have been proven over time in other states, adapting them to state-specific needs.
- Provide both "hard numbers" on quantitative impacts and process feedback on the effectiveness of program operations and methods for improving delivery.
- Use independent third parties, preferably with strong reputations for quality and unbiased analysis.
- Measure program success against stated objectives, providing information that is detailed enough to be useful and simple enough to be understandable to nonexperts.
- Provide for consistent and transparent evaluations across all programs and administrative entities.
- Communicate results to decisionmakers and stakeholders in ways that demonstrate the benefits of the overall program and individual market initiatives.
- Maintain a functional database that records customer participation over time and allows for reporting on geographical and customer class results.

Some states incorporate specific reporting and evaluation requirements into their energy plans and include feedback loops to guide future iterations of the plan. For example, Oregon's Biennial Energy Plan (2003–2005) includes a section that reviews the previous year's achievements. The Iowa Department of Natural Resources prepares a comprehensive energy plan update every two years, reporting on energy consumption and progress in improving energy efficiency and expanding renewable energy use. Many states require evaluation activities to be incorporated into an ongoing program planning, design, implementation, and evaluation cycle to meet multiple objectives. For example, the New York State Energy Research and Development Agency (NYSERDA) conducts evaluations to:

- Identify program goals and key output and outcome measures that provide indicators of program success.
- Review measurement and verification (M&V) protocols used to evaluate programs and verify energy savings estimates to determine if estimates are reasonably accurate.

- Evaluate program processes to determine how and why programs deliver or fail to deliver expected results.
- Characterize target markets, determine changes observed in the market, and identify the extent to which these changes can be attributed to the state's energy efficiency programs.
- Communicate with decisionmakers and stakeholders about the benefits of the overall efficiency program and results of individual programs.
- Refine program delivery models based on evaluation findings (NYSERDA 2004b).

Evaluation addresses different objectives at various stages of program design and implementation. Thus, what is measured depends on the implementation phase and the specific program component being evaluated. Table B.2 presents a hypothetical example of when evaluation activities could be conducted throughout the life of a program, recognizing that program evaluation is a dynamic process.

Managing Evaluation Activities

Since evaluation is complex, and different types of evaluation are needed at various stages of program design and implementation, states may wish to tap into their energy efficiency advisory group, form a

Table B.2: Examples of Evaluation Activities by Energy Efficiency Program Phase

Program Phase	Common Evaluation Activities	
Pre-Program Research and Assessment	• Perform needs assessment. • Establish baseline and research markets.	• Perform scoping study (e.g., define program objectives).
Program Design, Research, and Evaluation	• Develop and document theory of how program will work (i.e., a "program logic model"). • Define program outcomes. • Assess cost-effectiveness. • Establish indicators of, and metrics for, program performance.	• Identify data sources and specify data quality objectives. • Establish evaluation management plan. • Incorporate program refinements into formal program design.
Pilot Program	• Test concepts and program logic. • Measure participant satisfaction. • Assess measurement methods and program scope.	• Incorporate program refinements into formal program design. • Analyze implementation processes.
Full-Scale Implementation	• Track and monitor established indicators. • Report on program performance according to planned schedule. • Introduce program refinements. • Incorporate program refinements into formal program design.	• Adjust data collection and reporting needs as necessary. • Analyze implementation processes.
Mature Program	• Reassess adequacy of program logic; update as needed. • Estimate costs and benefits. • Assess progress against indicators. • Report on progress toward goals. • Introduce program refinements.	• Incorporate program refinements into formal program design. • Assess measurement methods. • Assess program effectiveness in terms of end results. • Assess impacts attributable to the program.

Source: Compiled by EPA based on multiple sources.

separate evaluation advisory group, or hire a professional advisor to guide evaluation investments. These entities can help assess available resources, identify and help prioritize evaluation activities, determine areas of uncertainty in a program or portfolio, and assess the maturity of a program. For example, advisors can be used to help identify and prioritize which assumptions used in the portfolio planning and cost-effectiveness screening process may need to be reassessed based on the parameters that are most uncertain or sensitive (e.g., if estimated incorrectly, could greatly affect overall savings estimates) or the programs or measures that account for the majority of portfolio savings estimates. Parameters may include:

- Hours of use.
- Assumed life of the measure (e.g., number of years that the product, home, or building will perform efficiently).
- Individual customer's interaction with the product, home, or building.
- Accuracy of engineering estimates (e.g., how a product performs in a lab or engineering simulation compared with how it performs after installation).

Identifying and reassessing potential weaknesses early in the process can help improve subsequent year program plans and forecasts and help ensure that no major surprises are uncovered during the impact evaluation process (described below in *Conducting Impact Evaluation*). In addition, an advisory group can help determine which evaluation activities are best managed by the implementing organization and which should be managed by another, third-party organization. The California Measurement Advisory Council (CALMAC) is an example of a highly sophisticated advisory group. CALMAC provides the state with a forum for developing, implementing, and reviewing evaluation studies related to its public benefits fund [PBF]-based energy efficiency programs (CALMAC 2005).

Measuring Energy Savings

States are measuring their energy efficiency savings using strategies and protocols that are increasingly credible, transparent, and consistently applied. The main elements and issues to be considered when conducting an impact evaluation, evaluating a market-based efficiency program, or adopting project-level M&V protocols are described as follows.

Conducting Impact Evaluation

An evaluation of program impacts is designed to identify and measure energy savings and other program impacts. Impact evaluation assesses the net effect of a program by comparing program impacts with an estimate of what would have happened in the absence of a program. In the context of energy efficiency, this typically includes an estimate of the energy reduction and peak reduction impacts. Impact evaluations review each of the assumptions used in energy and peak savings claims, in addition to the current market penetration of the energy-efficient product or service compared to the baseline.

Impact evaluation also typically addresses the impact of "free riders" (i.e., people who participate in the energy efficiency program, but who would have taken the energy efficiency action without the program) and sometimes addresses "free drivers" (i.e., people who are influenced into action by the program, but don't participate in the program). Several states, including New York, California, Connecticut, Oregon, and Wisconsin, have conducted comprehensive impact evaluations of their PBF programs for energy efficiency. For example, NYSERDA measures and tracks its PBF investments and conducts quarterly and annual evaluations of the Energy $mart program. It analyzes the cost-effectiveness of the program, permanent and peak-load energy and cost-savings to customers, economic impacts, and reductions in greenhouse gases and criteria pollutants (NYSERDA 2004b).

Considerations for Market-Based Energy Efficiency Programs

Market-based energy efficiency programs are designed to create a lasting change in the availability and selection of energy-efficient alternatives. In addition, benefits of a market-based program design include greater adoption of efficiency offerings and spillover effects (i.e., the effect of a program to induce other customers to invest in energy efficiency even without a program incentive). These programs often rely on existing market channels (e.g., retailers and contractors) for delivery and operate on the principle that inherent barriers need to be overcome for a customer to choose an energy-efficient product, home, building, or service. Market-based efficiency programs deploy a series of interventions to overcome those barriers and foster lasting change.

Market-based energy efficiency programs can be a highly cost-effective part of an energy efficiency program portfolio, but because they interact with established markets for products and services—and in many cases work closely with national programs such as ENERGY STAR (ENERGY STAR 2005)—it is important that new programs establish and document baselines and articulate program theory or logic from the onset. Establishing a baseline involves determining the current market share for the high-efficiency product or service and then projecting how the market would change over time in the absence of the program. Articulating the program theory or logic involves assessing the barriers to greater adoption, the program activities or interventions that will overcome these barriers, and the indicators that will be used to determine if the program is working as anticipated. Sample barriers, interventions, and indicators are summarized in Table B.3. Documenting the baseline and program theory lays the foundation for assessing and correcting problems with program design and sets the stage for eventual impact evaluation.

Adopting Project-Level Measurement and Verification (M&V) Protocols

Many states with active energy efficiency programs rely on accepted practices and methods approved by their respective regulatory commissions as the basis for measuring and verifying energy efficiency savings. Some states (e.g., Texas and California) have gone further and documented the key assumptions used to calculate energy and demand savings in a technical reference manual, providing a level of transparency. Other states reference specific verification protocols (i.e., specifying a required verification methodology or level of rigor). Without formal evaluation protocols, states will not have access to readily available and transparent energy savings data.

To improve the consistency, accuracy, and comparability of their efficiency initiatives, a number of states have adopted the International Performance Measurement and Verification Protocol (IPMVP). The IPMVP is an accepted industry standard that provides an overview of best practice techniques for verifying energy savings from facility-level and other efficiency initiatives. It is used by California, Florida, Iowa, Texas, New York, and Illinois to support system planning needs, clean energy portfolio standards, and carbon reduction programs (IPMVP 2005). EPA also

Table B.3: Issues to Consider When Documenting Energy Efficiency Program Logic

Barriers	Interventions	Mid Term Indicators	Long Term Indicators
• Lack of awareness. • Lack of supply. • Higher first cost.	• Consumer education. • Supplier education and incentives. • Education on reduced operating costs. • Financial incentives (e.g., rebate, buy-down).	• Increased awareness. • Increased supply of product or service. • Increased knowledge. • Use of financial incentive.	• Behavior change. • Change in manufacturing practice. • Reduction in price premium.

Source: Compiled by EPA based on multiple sources.

recommends the protocol to states participating in the NO_x SIP Call program.[51] The objectives of the IPMVP are to:

- Increase certainty, reliability, and savings level (with a focus on the persistence of savings several years after installation).
- Reduce transaction costs by providing an international, industry consensus approach and methodology.
- Reduce financing costs by providing project M&V standardization, thereby allowing project bundling and pooled project financing.
- Provide a basis for demonstrating emission reduction and delivering enhanced environmental quality.
- Provide a basis for negotiating contractual terms to ensure that an energy efficiency project achieves or exceeds its goals of saving money and improving energy efficiency (Seattle 2006).

The IPMVP provides a flexible set of M&V approaches (see Options A, B, C and D in Table B.4) for evaluating energy savings in buildings. These four options are designed to match project costs and savings requirements with particular efficiency measures and technologies (Fine and Weil 2000). Each option is applicable to different programs and projects based on factors such as the complexity of the efficiency measures under evaluation and the risk expectations. Accordingly, each option varies in accuracy and cost of implementation, as well as strengths and limitations.

Coordinating with Other States and Regions

State adoption of evaluation protocols is critical as policymakers and regulators turn to energy efficiency as a least-cost, short-term strategy to help meet regional transmission needs, offset increasing energy costs, and comply with multi-state commitments to reduce air emissions. States are increasingly complementing their existing energy efficiency policies (e.g., building energy codes, appliance standards, and public benefits charge-funded programs) with strategies that treat efficiency as a resource in the context of regional energy system and environmental frameworks. States can adopt credible and transparent evaluation protocols to advance a range of regional policies and initiatives, including the following:

- *Integrating Energy Efficiency into Resource Procurement Processes*. Developing consistent protocols to measure, verify, and report efficiency savings in a region can help states and regions evaluate the energy efficiency resource on a comparable basis with electricity generation resources in the context of clean energy portfolio standards, portfolio management, and demand response programs. A common evaluation protocol allows efficiency savings to be readily compared, aggregated, and ultimately integrated into broader system plans.
- *Serving As the Basis for Documenting Emission Reductions Associated with Energy Efficiency Programs/Projects*. As states and regions encourage energy efficiency as an emission reduction strategy under regulatory "cap and trade" programs, accurate and transparent evaluation protocols for energy savings are necessary to document reductions and secure credits associated with energy efficiency programs and projects. Texas and Wisconsin are among the states and regions that have analyzed the emission impacts associated with their state's energy efficiency programs. In Wisconsin, the evaluation team developed emission factors for the marginal generating units for different time periods (e.g., peak and off-peak hours during the winter and summer) and used these factors to analyze the effects of different energy efficiency programs (Erickson et al. 2004).
- *Improving Regional Energy Efficiency Modeling and Forecasting*. Various state and regional energy modeling efforts (e.g., efficiency potential studies and regional climate change modeling) require a consistent characterization of energy efficiency projects and programs. This includes estimates of savings and costs, as well as how efficiency savings assumptions are likely to change in the future.

[51] These and other M&V resources are described in the EPA report, Creating an Energy Efficiency and Renewable Energy Set-Aside in the NO_x Budget Trading Program: Measuring and Verifying Energy Savings (EPA forthcoming).

Table B.4: IPMVP Measurement and Verification Options

M&V Option	How Savings Are Calculated	Cost	Typical Applications
Option A. Partially Measured Retrofit Isolation: Savings determined by partial field measurement of the energy use of the system to which a measure was applied, separate from the energy use of the rest of the facility. Focuses on physical assessment of equipment changes to ensure the installation is to specification. Key performance factors (e.g., lighting wattage or chiller efficiency) are determined with spot or short-term measurements. Operational factors (e.g. lighting operating hours or cooling ton-hours) are stipulated based on analysis of historical data or spot/short-term measurements. Performance factors and proper operation are measured or checked annually.	Engineering calculations using spot or short-term measurements, computer simulations, and/or historical data.	Dependent on number of measurement points. Approximately 1% to 5% of project construction cost of items subject to M&V.	Lighting retrofit where power draw is measured periodically. Operating hours of the lights are assumed to be one-half hour per day longer than a store's open hours.
Option B. Retrofit Isolation: Savings determined after project completion by short-term or continuous measurements taken throughout the term of the contract at the device or system level. Performance and operations factors are monitored.	Engineering calculations using metered data.	Dependent on number and type of systems measured and the term of analysis/metering. Typically 3% to 10% of project construction cost of items subject to M&V.	Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the base year, this meter is in place for a week to verify constant loading. The meter is in place through the post-retrofit period to track variations in energy use.
Option C. Whole Facility: After project completion, savings determined at the "whole-building" or facility level using current year and historical utility meter (gas or electricity) or sub-meter data. Short-term or continuous measurements are taken throughout the post-retrofit period.	Analysis of utility meter (or sub-meter) data using techniques from simple comparison to multivariate (hourly or monthly) regression analysis.	Dependent on number and complexity of parameters in analysis. Typically 1% to 10% of project construction cost of items subject to M&V.	Multi-faceted energy management program affecting many systems in a building. Energy use is measured by gas and electric utility meters for a twelve-month base year period and throughout the post-retrofit period.
Option D. Calibrated Simulation: Savings determined through simulation of facility components and/or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility.	Calibrated energy simulation/modeling; calibrated with hourly or monthly utility billing data and/or end-use metering.	Dependent on number and complexity of systems evaluated. Typically 3% to 10% of project construction cost of items subject to M&V.	Multi-faceted energy management program affecting many systems in a building but where no base year data are available. Post-retrofit period energy use is measured by gas and electric utility meters. Base year energy use is determined by simulation using a model calibrated by the post-retrofit period utility data.

Sources: IPMVP 2002 and Seattle 2006.

- *Incorporating energy efficiency more effectively into regional electric power system planning*. Consistent evaluation and reporting protocols are necessary to determine the total impact that energy efficiency can have within a regional electricity system. Similarly, a common reporting protocol allows two or more adjoining power pools to ensure consistency when analyzing interchange and trade activities.
- *Assessing the impact of energy efficiency on reducing natural gas demand for electric power generation*. Energy efficiency can play a significant role in reducing forecasted natural gas demand. Common protocols for efficiency savings help policymakers, system planners, and other analysts increase the accuracy and reliably of estimates of the impact that efficiency initiatives can have on natural gas demand.
- *Improving the comparability of energy efficiency program cost and value in a region*. Greater consistency in the methods used to determine the cost (e.g., $/kWh) and value (e.g., avoided generation, and T&D costs) of energy efficiency projects and programs allows for better comparison of efficiency relative to other resources. It also allows policymakers, regulators, program administrators, and other parties to more reliably compare program performance across states (NEEP 2006).

Information Resources

Developing Program Cost Estimates

	Title/Description	URL Address
California	**Regulatory–Energy Efficiency Filings**. Monthly Program Reports. This Web site contains monthly program reports on energy efficiency filed by Southern California Edison.	www.sce.com/AboutSCE/Regulatory/eefilings/MonthlyReports.htm
Minnesota	**Electric and Gas Conservation Improvement Program Biennial Plan for 2005 and 2006**. Docket No. E, G002/CIP-04. Submitted to the Minnesota Department of Commerce by Xcel Energy. June 1, 2004.	URL not available.
New York	**New York Energy $mart Program Cost-Effectiveness Assessment**. This report is a benefit-cost analysis to assess the cost-effectiveness of 18 individual New York Energy $mart public benefits programs.	http://www.nyserda.org/Energy_Information/ContractorReports/Cost-Effectiveness_Report_June05.pdf
Northwest	**The Fifth Northwest Electric Power and Conservation Plan**. Document 2005-7. This plan is a blueprint for an adequate, low-cost, and low-risk energy future. Technical appendices include conservation cost-effectiveness methodologies.	http://www.nwcouncil.org/energy/powerplan/plan/Default.htm
Vermont	**Efficiency Vermont. 2002 Annual Report**. The Power of Efficient Ideas. This summary highlights the 2002 accomplishments of Efficiency Vermont.	http://www.efficiencyvermont.org/index.cfm?L1=292&L2=535&L3=537&sub=bus or Contact Efficiency Vermont at 1-888-921-5990.

Cost-Effectiveness Tests

	Title/Description	URL Address
California	**The California Standard Practice Manual: Economic Analysis of Demand Side Programs and Projects**. This manual describes cost-effectiveness procedures for conservation and load management programs from four major perspectives: Participant, Ratepayer Impact Measure (RIM), Program Administrator Cost (PAC), and Total Resource Cost (TRC). A fifth perspective, the Societal test, is treated as a variation on the TRC test.	http://drrc.lbl.gov/pubs/CA-SPManual-7-02.pdf
Oregon	**Cost Effective Policy and General Methodology for the Energy Trust of Oregon**. This report describes the Energy Trust of Oregon's policy for analyzing the cost-effectiveness of its energy efficiency investments. This policy encompasses three generic perspectives—Consumer, Utility System, and Societal.	http://www.energytrust.org/Pages/about/library/policies/4.06_CostEffect.pdf
All States	**Tools and Methods for Integrated Resource Planning: Improving Energy Efficiency and Protecting the Environment**. This report provides information on calculating and analyzing the cost effectiveness of energy conservation measures against supply-side options, as well as methods for integrated resource planning.	http://uneprisoe.org/IRPManual/IRPmanual.pdf

Deemed Savings

	Title/Description	URL Address
California	**2005 Measure Cost Study**. Final Report. CALMAC Study ID: PGE0235.01 This report provides cost information on the non-weather-sensitive and weather-sensitive residential and nonresidential measures and refrigeration measures that are included in the Database for Energy Efficiency Resources (DEER) and used by energy efficiency program planners in California to estimate potential demand and energy savings and costs.	http://calmac.org/publications/MCS_Final_Report.pdf
New Jersey	**New Jersey Clean Energy Program Protocols to Measure Resource Savings**. These protocols were developed to measure energy capacity and other resource savings. Specific protocols are presented for each eligible measure and technology.	http://www.njcleanenergy.com/media/Protocols.pdf
Texas	**Deemed Savings, Installation & Efficiency Standards. Residential and Small Commercial Standard Offer Program, and Hard-to-Reach Standard Offer Program**. This document contains all of the approved energy and peak demand deemed savings values established for energy efficiency programs in Texas.	http://www.puc.state.tx.us/rules/subrules/electric/25.184/25.184fig(d)(1).pdf
Vermont	**Technical Reference User Manual (TRM) No. 4-19. Measure Savings Algorithms and Cost Assumptions Through Portfolio 19**. Efficiency Vermont provides a set of deemed-savings methods in this manual.	http://www.efficiencyvermont.org/ or Contact Efficiency Vermont at 1-888-921-5990.

National Energy Efficiency Potential Analyses

Title/Description	URL Address
Emerging Energy-Saving Technologies and Practices for the Buildings Sector As of 2004. This study identifies new research and demonstration projects that could help advance high-priority emerging technologies, as well as new potential technologies and practices for market transformation activities.	http://aceee.org/pubs/a042toc.pdf
A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the U.S. Electricity System. This report develops a scenario for the future evolution of the electric power system in the U.S., including increased investment in energy efficiency and in renewable and distributed generating technology, and compares it with the current situation.	http://uspirg.org/reports/AResponsibleElectrictyFuture.pdf
Scenarios for a Clean Energy Future, 2000. This document reflects efforts of the Interlaboratory Working Group, commissioned by the U.S. Department of Energy, to examine the potential for public policies and programs to foster efficient and clean energy technology solutions.	http://www.ornl.gov/sci/eere/cef/
Screening Market Transformation Opportunities: Lessons from the Last Decade, Promising Targets for the Next Decade. This report examines past and recent trends in the market transformation field and presents an updated screening analysis and categorization of the most promising opportunities.	http://www.aceee.org/pubs/u022full.pdf
The Technical, Economic and Achievable Potential for Energy Efficiency in the U.S.—A Meta-Analysis of Recent Studies. This study compares the findings from eleven studies on the technical, economic, and/or achievable potential for energy efficiency in the U.S. to recent-year actual savings from efficiency programs in leading states.	http://www.aceee.org/conf/04ss/rnemeta.pdf

Regional Energy Efficiency Potential Analyses

	Title/Description	URL Address
Midwest	**Examining the Potential for Energy Efficiency to Address the Natural Gas Crisis in the Midwest**. The results of this study suggest that a modestly aggressive, but pragmatically achievable, energy efficiency campaign (achieving about a 5% reduction in both electricity and natural gas customer use over five years) could produce tens of billions of dollars in net cost savings for residential, commercial, and industrial customers in the Midwest.	http://www.aceee.org/pubs/u051.htm
	Repowering the Midwest: The Clean Energy Development Plan for the Heartland. This Web site is supported by the Environmental Law and Policy Center as a source for clean energy information in the Midwest. It provides information on the Clean Energy Development Plan for the Heartland, which proposes policies to implement underutilized energy efficiency technologies and to aggressively develop renewable energy resources.	http://www.repowermidwest.org/

	Title/Description	URL Address
Northeast	**Economically Achievable Energy Efficiency Potential in New England**. This report provides an overview of areas where energy efficiency could potentially be increased in the six New England states.	http://www.neep.org/files/Updated_Achievable_Potential_2005.pdf
	Electric Energy Efficiency and Renewable Energy in New England: An Assessment of Existing Policies and Prospects for the Future. This report applies analytical tools, such as economic and environmental modeling, to demonstrate the value of consumer-funded energy efficiency programs and renewable portfolio standards and addresses market and regulatory barriers.	http://raponline.org/Pubs/RSWS-EEandREinNE.pdf
	NEEP Initiative Review: Commercial/Industrial Sectors Qualitative Assessment and Initiative Ranking. The purpose of this study is to assist Northeast Energy Efficiency Partnerships, Inc. (NEEP) in reviewing the value and future role of existing and potential residential initiatives through a scoring and ranking system that was developed to provide a consistent means of comparing the initiatives.	www.neep.org/html/NEEP_C&IReview.pdf
	NEEP Strategic Initiative Review: Qualitative Assessment and Initiative Ranking for the Residential Sector. Synapse Energy Economics. Submitted to Northeast Energy Efficiency Partnerships, Inc., October 1, 2004.	http://www.neep.org/html/NEEP_ResReview.pdf
Northwest	**The Fifth Northwest Electric Power and Conservation Plan. Document 2005–2007**. This plan is a blueprint for an adequate, low-cost, and low-risk energy future. Technical appendices include conservation cost-effectiveness methodologies.	http://www.nwcouncil.org/energy/powerplan/plan/Default.htm
Southeast	**Powering the South, A Clean & Affordable Energy Plan for the Southern United States.** Powering the South shows that a clean generation mix can meet the region's power demands and reduce pollution without raising the average regional cost of electricity and lists the policy initiatives that can make the changes.	http://poweringthesouth.org/report/
Southwest	**The Potential for More Efficient Electricity Use in the Western U.S.: Energy Efficiency Task Force Draft Report to the Clean and Diversified Energy Advisory Committee of the Western Governor's Association, Draft Report for Peer Review and Public Comment**. This report demonstrates how the adoption of best practice energy efficiency policies and programs in all western states could reduce most of projected load growth during 2005–2020, reduce overall electricity consumption, and yield economic and environmental benefits.	http://www.westgov.org/wga/initiatives/cdeac/Energyefficiencydraft9-15.pdf
	The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest. This report for the Southwest Energy Efficiency Project examines the potential for and benefits from increasing the efficiency of electricity use in the southwest states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming.	http://www.swenergy.org/nml/index.html
	Economic Assessment of Implementing the 10/20 Goals and Energy Efficiency Recommendations. This report examines the Grand Canyon Visibility Transport Commission air pollution prevention recommendations. It articulates the potential emission reductions, costs, and secondary economic impacts of meeting the 10/20 goals and implementing the energy efficiency recommendations given the assumptions and scenarios developed by the Air Pollution Prevention (AP2) forum.	http://www.wrapair.org/forums/ap2/docs.html

	Title/Description	URL Address
Southwest	A Balanced Energy Plan for the Interior West. This report shows how energy efficiency, renewable energy, and combined heat and power resources can be integrated into the region's existing power system to meet growing electric demands in a way that is cost-effective, reduces risk, is reliable, and improves environmental quality for the Interior West region of Arizona, Colorado, Montana New Mexico, Nevada, Utah, and Wyoming.	http://westernresources.org/energy/bep.html

State Energy Efficiency Potential Analyses/Energy Strategies

	Title/Description	URL Address
California	California's Secret Energy Surplus: The Potential for Energy Efficiency. This study focuses on assessing electric energy efficiency potential in California through the assessment of technical, economic, and achievable potential savings over the next 10 years.	http://www.ef.org/documents/Secret_Surplus.pdf
Connecticut	Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region. This study estimates the maximum achievable cost-effective potential for electric energy and peak demand savings from energy efficiency measures in the geographic region of Connecticut served by United Illuminating Company and Connecticut Light and Power Company.	http://www.env-ne.org/Publications/CT_EE_MaxAchievablePotential%20Final%20Report-June%202004.pdf
Georgia	Assessment of Energy Efficiency Potential in Georgia. This report presents a profile of energy use in Georgia, the potential for, and public benefits of, energy efficiency, and a public policy review.	http://www.gefa.org/pdfs/assessment.pdf
Iowa	The Potential for Energy Efficiency in Iowa. This report uses existing programs, surveys, savings calculators, and economic simulation to estimate the potential for energy savings in Iowa.	http://www.ornl.gov/sci/btc/apps/Restructuring/IowaEEPotential.pdf
Massachusetts	The Remaining Electric Energy Efficiency Opportunities in Massachusetts. This report addresses the remaining electric energy efficiency opportunities in the residential, commercial, and industrial sectors in Massachusetts.	http://www.mass.gov/doer/pub_info/e3o.pdf
Nevada	Nevada Energy Efficiency Strategy. Nevada has taken a number of steps to increase energy efficiency. This report provides 14 policy options for further increasing the efficiency of electricity and natural gas and reducing peak power demand.	http://www.swenergy.org/pubs/Nevada_Energy_Efficiency_Strategy.pdf
New Jersey	New Jersey Energy Efficiency and Distributed Generation Market Assessment. This study estimates mid- and long-term potential for energy and peak-demand savings from energy efficiency measures and for distributed generation in New Jersey.	http://www.bpu.state.nj.us/cleanEnergy/KemaReport.pdf

	Title/Description	URL Address
New York	**Energy Efficiency And Renewable Energy Resource Development Potential In New York State. Final Report Volume One: Summary Report**. This study examines the long-range potential for energy efficiency and renewable energy technologies to displace fossil-fueled electricity generation in New York by looking at the potential available from existing and emerging efficiency technologies and practices and by estimating renewable electricity generation potential.	http://www.nyserda.org/publications/EE&ERpotentialVolume1.pdf
Oregon	**Energy Efficiency and Conservation for the Residential, Commercial, Industrial, and Agricultural Sectors**. This report is designed to inform the project development and selection process for a list of potential energy efficiency and renewable energy measures that could provide electricity savings for Oregon consumers.	http://www.energytrust.org/Pages/about/library/reports/Resource_Assesment/ETOResourceAssessFinal.pdf
	Natural Gas Efficiency and Conservation Measure Resource Assessment for the Residential and Commercial Sectors. This is a resource assessment to evaluate potential natural gas conservation measures that can be applied to the residential and commercial building stock serviced by Northwest Natural Gas.	http://www.energytrust.org/Pages/about/library/reports/Resource_Assesment/GasRptFinal_SS103103.pdf
Pennsylvania	**Economic Impact of Renewable Energy in Pennsylvania. Final Report**. This report presents an analysis of the potential economic impacts of renewable energy development in Pennsylvania spurred by a renewable portfolio standard.	http://www.bv.com/energy/eec/studies/PA_RPS_Final_Report.pdf
Wisconsin	**Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin**. The Governor's Task Force on Energy Efficiency and Renewables commissioned the Energy Center of Wisconsin to estimate the achievable potential for energy efficiency and customer-sited renewable energy.	http://energytaskforce.wi.gov/section.asp?linkid=34

Evaluation and Measurement and Verification Resources

Title/Description	URL Address
Applications Team: Energy-Efficient Design Applications. This site provides numerous resources, ranging from implementation guidelines to checklists and other resources, to help organizations implement an M&V program.	http://ateam.lbl.gov/mv/
ASHRAE Guideline 14-2002. **Measurement of Energy and Demand Savings. American Society of Heating, Refrigerating and Air Conditioning Engineers.** June 2002. This guidance describes how to reliably measure energy savings of commercial equipment, using measured pre- and post-retrofit data.	http://www.ashrae.org/template/AssetDetail/assetid/15275
California's 2003 Non-Residential Standard Performance Contract Program M&V Procedures Manual. This manual provides general guidelines for preparing an M&V plan, choosing an M&V option and method, defining and adjusting baselines, and collecting and submitting M&V data.	http://www.pge.com/docs/pdfs/biz/rebates/spc_contracts/2000_on_peak_incentive/III-m&v.pdf http://www.pge.com/spc

Title/Description	URL Address
The California Evaluation Framework, prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004. The California Evaluation Framework provides a consistent, systemized, cyclic approach for planning and conducting evaluations of California's energy efficiency and resource acquisition programs. It provides information on when evaluations should be conducted, the types of evaluation that can be conducted, and approaches for conducting these studies.	http://www.fypower.org/feature/workshop_docs/workshop_5/ca_eval_framework_0604.pdf
California Measurement Advisory Council Web Site. California's statewide CALMAC evaluation clearinghouse contains resources for deemed savings and project-specific M&V techniques.	http://www.calmac.org
The CEE Market Assessment and Program Evaluation Clearinghouse (MAPE). This is a fully searchable Web-based database that contains more than 300 evaluation reports, market characterization studies, and market assessments.	http://www.cee1.org/eval/clearinghouse.php3
Creating an Energy Efficiency and Renewable Energy Set-Aside in the NO_x Budget Trading Program: Measuring and Verifying Electricity Savings. This forthcoming EPA report describes key M&V resources.	Contact EPA.
EE/RE Measurement and Verification and Emissions Quantification: General Considerations State Technical Forum on EE/RE Call #3, December 16, 2004. This is a PowerPoint presentation comparing M&V with emissions quantification procedures.	http://www.keystone.org/Overview_M_and_V_Dec_16.pdf
Electric and Gas Conservation Improvement Program Biennial Plan for 2005 and 2006. Docket No. E, G002/CIP-04. This plan was submitted to the Minnesota Department of Commerce by Xcel Energy, June 1, 2004.	URL not available.
Evaluation, Measurement and Verification Workshop. The California Public Utilities Commission (CPUC) held several workshops on EM&V. The primary purpose of these workshops was to discuss the performance basis, metrics, and protocols for evaluating and measuring energy efficiency programs, including incentive, training, education, marketing, and outreach programs.	http://www.fypower.org/feature/workshops/workshop_5.html The final Decision can be found at: http://www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/45783.htm
The Fifth Northwest Electric Power and Conservation Plan. May 2005. Document 2005-7. This plan is a blueprint for an adequate, low-cost, and low-risk energy future. Technical appendices include conservation cost-effectiveness methodologies.	http://www.nwcouncil.org/energy/powerplan/Default.htm
Highly Cost-Effective Savings—Appliance Efficiency Standards and Utility Programs. August 18, 2005. Douglas Mahone. Heschong Mahone Group, Inc. This is a presentation made at the 2005 IEPEC Program Evaluation conference.	http://www.iepec.org/index_agenda.htm
International Energy Program Evaluation Conference Abstracts. This Web site provides abstracts of peer-reviewed evaluation research from past conferences.	http://www.iepec.org/index_abstractsonline.htm
International Performance Measurement and Verification Protocol Web Site. IPMVP Inc. is a nonprofit organization that develops products and services to aid in the M&V of energy and water savings resulting from energy/water efficiency projects—both retrofits and new construction. The site contains the IPMVP, a series of documents for use in developing an M&V strategy, monitoring indoor environmental quality, and quantifying emission reductions.	www.ipmvp.org
New York State Energy Research and Development Authority (NYSERDA) Standard Performance Contracting Program Measurement and Verification Guideline, 2003. This Web site presents NYSERDA's New York Energy $mart program application and guidelines for contractors for performance-based incentives to implement cost-effective electrical efficiency improvements or summer demand reduction for eligible customers.	http://www.nyserda.org/funding/855PON.html

Title/Description	URL Address
Oncor Commercial & Industrial Standard Offer Program 2003. Measurement and Verification Guidelines. These M&V guidelines include retrofit and new construction and default savings values for lighting, motors, and air conditioning equipment.	http://www.oncorgroup.com/electricity/teem/candi/default.asp
Standardized Methods for Free-Ridership and Spillover Evaluation—Task 5 Final Report. June 16, 2003. PA Knowledge Limited sponsored by National Grid, NSTAR Electric, Northeast Utilities, Unitil and Cape Light Compact. This report is used by Massachusetts utilities to estimate free ridership and spillover effects.	Contact PA Consulting at: http:///www.paconsulting.com
Technical Reference User Manual (TRM) No. 4-19. Measure Savings Algorithms and Cost Assumptions Through Portfolio 19. Efficiency Vermont provides a set of deemed-savings methods in this manual.	http://www.efficiencyvermont.org/ or Contact Efficiency Vermont at 1-888-921-5990.
Texas Public Utilities Commission. Measurement and Validation Guidelines. May 25, 2005. This report, conducted as part of the Texas PUC Energy Efficiency Implementation project #30331, includes detailed information about the M&V requirements of the Commercial and Industrial Standard Offer Program, as well as guidance for project sponsors on how to prepare and execute an M&V plan.	http://www.puc.state.tx.us/electric/projects/30331/052505/m%26v%5Fguide%5F052505.pdf

References

Title/Description	URL Address
Biewald, B., T. Woolf, A. Roschelle, and W. Steinhurst. 2003. Synapse Energy Economics, Portfolio Management: How to Procure Electricity Resources to Provide Reliable, Low-Cost, And Efficient Electricity Services to All Retail Customers. October 10.	http://www.synapse-energy.com/Downloads/SynapseReport.2003-10.RAP.'Portfolio-Management'03-24.pdf
CALMAC. 2005. California Measurement Advisory Council Web Site.	http://www.calmac.org
Connecticut ECMB. 2004. Connecticut Energy Conservation Management Board. Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region. June.	http://www.env-ne.org/Publications/CT_EE_MaxAchievablePotential%20Final%20Report-June%202004.pdf
CPUC 2005. Interim Opinion: Energy Efficiency Portfolio Plans and Program Funding Levels for 2006–2008—Phase 1 Issues. Decision 05-09-043. (See pp. 122–123 and Attachment 6.) September 22.	http://www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/49859.htm
ECMB 2005. Energy Conservation Management Board. Energy Efficiency: Investing in Connecticut's Future. Prepared for the Connecticut Legislature Energy &Technology Committee, Environment Committee. March 1.	http://www.env-ne.org/Publications/ECMB%20Annual%20Legislative%20Report%202005.pdf
Efficiency Vermont. 2002. Annual Report. The Power of Efficient Ideas.	http://www.efficiencyvermont.org/ or Contact Efficiency Vermont at 1-888-921-5990.

References (*continued*)

Title/Description	URL Address
ENERGY STAR 2005. ENERGY STAR Web Site. Partner Resources: Service & Product Providers. Accessed December 2005.	http://www.energystar.gov/index.cfm?c=spp_res.pt_spps
EPA. Forthcoming Report. Creating an Energy Efficiency and Renewable Energy Set-Aside in the NO_x Budget Trading Program Measuring and Verifying Electricity Savings.	Contact EPA.
EPA. 2006. Energy Efficiency Best Practices. Draft Report to the Energy Efficiency Action Plan Leadership Group. Final report will be available in the summer of 2006.	http://www.epa.gov/cleanenergy/eeactionplan.htm
Erickson, J., C. Best, D. Sumi, B. Ward, B. Zent, and K. Hausker. 2004. Estimating Seasonal and Peak Environmental Emission Factors—Final Report. Prepared by PA Governmental Services for the Wisconsin DOA. May 21.	http://www.doa.state.wi.us/docs_view2.asp?docid=2404
Fine, S. and C. Weil. 2000. Crediting Energy Efficiency Measures Under Air Emissions Programs. ICF Consulting and U.S. Environmental Protection Agency. ACEEE Summer Study on Energy Efficiency in Buildings. 2000.	http://www.icfconsulting.com/Publications/doc_files/CreditingEEMeasures.pdf
Geller. 2006. Personal communication with Howard Geller, Southwest Energy Efficiency Project (SWEEP). March 1.	N.A.
IPMVP. 2005. Efficiency Valuation Organization. International Performance Measurement and Verification Protocol Web Site.	http://www.ipmvp.org/
IPMVP. 2002. International Performance Measurement & Verification Committee. International Performance Measurement & Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1. DOE/GO-10202-1554. March.	http://www.ipmvp.org/Documents/ipmvp-vol1.pdf
Kim, H., Project Manager. Energy Analysis, NYSERDA, May 5, 2005. Calculated based on data from New York Energy $mart Program Cost Effectiveness Assessment. December 2004.	N.A.
Nadel, S., A. Shipley, and R. N. Elliot. 2004. The Technical, Economic, and Achievable Potential for Energy Efficiency in the US—A Meta Analysis of Recent Studies. American Council for an Energy-Efficient Economy, Proceedings from the 2004 ACEEE Summer Study on Energy Efficiency in Buildings. August.	http://www.aceee.org/energy/eeassess.htm (Energy Efficiency Potential Assessments Web Site) http://www.aceee.org/conf/04ss/rnemeta.pdf (direct link)
NEDRI. 2003. Dimensions of Demand Response: Capturing Customer Based Resources in New England's Power Systems and Markets—Report and Recommendations of the New England Demand Response Initiative. Prepared for the New England Demand Response Initiative. July 23.	http://www.raponline.org/Pubs/General/FinalNEDRIREPORTJuly2003.pdf
NEEP. 2006. Northeast Energy Efficiency Partnerships, Inc. The Need for and Approaches to Developing Common Protocols to Measure, Verify and Report Energy Efficiency Savings in the Northeast. Final Report. January.	http://www.neep.org/files/Protocols_report.pdf

References (*continued*)

Title/Description	URL Address
The Northwest Power Planning Council. 2005. The Fifth Northwest Electric Power and Conservation Plan. Document 2005-7. May.	http://www.nwcouncil.org/energy/powerplan/plan/Default.htm
NYSERDA. 2004a. New York Energy $mart Program Evaluation and Status Report. Final Report. Volume I, Executive Summary, p. ES-30, New York State Energy Research and Development Authority. May.	http://www.nyserda.org/Energy_Information/04sbcreport.asp
NYSERDA. 2004b. NYSERDA Web Site. New York Energy $mart Program Evaluation. New York State Energy Research and Development Authority, Albany. September.	http://www.nyserda.org/Energy_Information/evaluation.asp
Optimal Energy. 2005. Economically Achievable Energy Efficiency Potential in New England. Prepared by Optimal Energy, Inc. for the Northeast Energy Efficiency Partnerships, Inc. May.	http://www.neep.org/files/Updated_Achievable_Potential_2005.pdf
Optimal Energy, Inc., ACEEE, Vermont Energy Investment Corp., Christine T. Donovan Associates. 2003. Energy Efficiency and Renewable Energy Resource Development Potential In New York State. Volume One: Summary Report. Prepared for NYSERDA. August.	http://www.nyserda.org/publications/EE&ERpotentialVolume1.pdf
Prindle, B. and N. Elliot. 2006. Personal communication with Bill Prindle and Neal Elliot, ACEEE, February 28.	N.A.
SCE. 2004. Southern California Edison. Regulatory—Energy Efficiency Filings. Program Summary Monthly Reports for SBC-funded programs. December.	http://www.sce.com/AboutSCE/Regulatory/eefilings/MonthlyReports.htm
Rufo, M. and F. Coito. 2002. California's Secret Energy Surplus: The Potential for Energy Efficiency. Prepared for the Energy Foundation and the Hewlett Foundation. Xenergy Inc. September 23.	http://www.ef.org/documents/Secret_Surplus.pdf
Seattle. 2006. Seattle Sustainable Development Web Site. General Introduction to the IPMVP. Accessed February 2006.	http://www.ci.seattle.wa.us/sustainablebuilding/Leeds/docs/IPMVP_summary.pdf
SWEEP. 2002. Southwest Energy Efficiency Project. The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest. Report for the Hewlett Foundation Energy Series. November.	http://www.swenergy.org/nml/
UNEP. 1997. Tools and Methods for Integrated Resource Planning: Improving Energy Efficiency and Protecting the Environment. United Nations Environment Programme (UNEP). Collaborating Centre on Energy and Environment. J. N. Swisher, G. de Martino Jannuzzi, and R. Y. Redlinger. November.	http://uneprisoe.org/IRPManual/IRPmanual.pdf
Xcel Energy. 2004. Minnesota. Electric and Gas Conservation Improvement Program Biennial Plan for 2005 and 2006.	Docket No. E, G002/CIP-04 Submitted to the Minnesota Department of Commerce by Xcel Energy, June 1, 2004.

Appendix C. Clean Energy Supply: Technologies, Markets, and Programs

This appendix provides an overview of the benefits of clean energy supply technologies, including renewable energy (i.e., wind, solar photovoltaics [PV], solar thermal, wind, biomass, geothermal, waste-to-energy, and landfill gas/biomass) and combined heat and power (CHP). It describes the key market issues and challenges related to developing these technologies and concludes with an overview of some of the emerging and innovative approaches that states can pursue to foster clean energy supply in their states.

Benefits of Clean Energy Supply

States are developing initiatives and taking actions aimed at bringing reliable sources of energy to the marketplace. State and local governments are finding that clean energy supply technologies have significant economic and environmental benefits, and therefore enjoy widespread public support. These benefits include:

- *Increased State Economic Development*. Clean energy technologies can promote economic development in a variety of ways. Clean energy projects create short-term construction and installation jobs and provide numerous long-term opportunities associated with new clean energy businesses. Alternative energy sources reduce fuel price volatility and increase fuel diversity, leading to a more stable energy supply portfolio that can be an important component of new economic growth. Renewable energy draws on local resources that can offset imports from out-of-state. Use of these in-state resources improves the state balance of trade and can create long-term economic value.
- *Reduced Energy-Related Environmental Pollution*. CHP reduces the amount of fuel input per unit of energy output and reduces the corresponding emissions of pollutants and greenhouse gases. Electricity from renewable resources generally does not contribute to global climate change or local air pollution. In particular, air emissions associated with generating electricity from solar, geothermal, and wind technologies are negligible, because no fuels are combusted in these processes. Producing electricity from LFG and biogas avoids the need to use nonrenewable resources to produce electricity.
- *Increased Power Reliability*. CHP and renewable energy, as distributed generation (DG), reduce electricity infrastructure vulnerability. DG facilities can help reduce congestion on the electric grid by removing or reducing load in areas of high demand. They can also be operated independently of the grid in the event of a disruption to central systems.
- *Increased Fuel Diversity*. Increased fuel diversity avoids over-reliance on a single fuel, which can cause disruption or price volatility if the supply of that fuel is constrained. Renewable energy technologies broaden the energy mix. CHP can use a variety of fuels, including natural gas, coal, biomass, and biogas.
- *Efficient Use of Natural Resources*. CHP requires less fuel for a given energy output, so it reduces the demand for finite natural resources, such as natural gas and coal. The average efficiency of fossil-fueled power plants in the United States is 33% and has remained virtually unchanged for 40 years. When purchased electricity is combined with onsite thermal generation (assuming 80% boiler efficiency), the typical combined efficiency is 49%. CHP systems typically achieve overall fuel efficiencies of 55% to 80% and reduce fuel use 20% to 50% over separate heat and power.

This improvement in efficiency is an excellent pollution prevention strategy that reduces emissions of air pollutants and carbon dioxide, the leading greenhouse gas associated with climate change. Furthermore, since CHP is located at the energy user's site, it reduces electric transmission and distribution losses (averaging 7% to10%), resulting in further efficiency gains and providing an efficient use of natural resources (e.g., coal and natural gas) through a highly optimized system producing two or more useful outputs from one fuel input. The use of renewable energy sources reduces fossil fuel consumption even further; unlike fossil fuels, renewable energy sources are sustainable and will not run out.

Clean Energy Technologies

A wide range of clean energy technologies can be used to generate electricity. Table C.1 compares key clean energy technologies. The remainder of this section presents a brief description of each technology.

Wind Power

Wind power is currently one of the most economically viable renewable energy resources. Key advantages include its relatively low capital cost (compared to other renewable energy options), low operating costs, and technological maturity. Wind power can also be developed in relatively large-scale projects (resources permitting), further reducing costs through economies of scale.

Table C.1: Comparison of Key Clean Energy Technology Options

	Wind Power	Solar PV[a]	Solar Thermal Electric[b]	Geothermal	Solid Biomass	Waste to Energy	Landfill Gas/Biogas	CHP
Typical Size Project	5–200 MW	0.1–1 MW	25kW–50 MW	5–100 MW	5–50 MW	5–50 MW	1–10 MW	25 kW–500 MW
Approximate U.S. Market Size (installed capacity in MW)	9,149[c]	300[d]	350	2,400[e]	6,500[f]	2,500[f]	1,200[f]	81,000
Typical Total Installed Cost ($/kW)[g]	1,200	6,000–8,000	3,900	2,350	1,500–2,500	4,000–6,000	1,300–1,500	800–2,500[h]
Typical Levelized Cost of Electricity Without Incentives in 2005 (¢/kWh)[i]	6–7	30–50	13	5	8.5–11	Varies[j]	4.5	5–9
Typical Levelized Cost of Electricity with Incentives in 2005 (¢/kWh)[k]	2.5–3.5	12–17	9	4	7.5–10	Varies[j]	3.5	Varies[j]

a Assumes PV is for distributed applications (e.g., residential and commercial rooftop applications) that compete with retail electric rates.
b Assumes solar thermal is the parabolic trough technology; a centralized solar concentrating system which produces electricity.
c Source: AWEA 2006 (data are for the end of 2005).
d Source: Navigant 2005.
e Source: Lund 2004.
f Sources: EIA 2004d, Kiser and Zannes 2004, EPA 2005.
g Source: Navigant 2005.
h Fuel cell CHP may be as high as 6,000.
i Source: Levelized Cost of Energy (LCOE) figures are from a proprietary Navigant Consulting model. Assumes projects are developer- (i.e., private sector) financed. Projects that are developed by municipal utilities or similar public sector entities can have lower LCOEs due to lower financing costs. However, there are also fewer financial incentives for public sector-funded projects.
j Cost of energy is highly dependent on tipping fees.
k The LCOE, as calculated with incentives, includes the range of current federal and state incentives applicable to the different technology options (e.g. production tax credit [PTC], investment tax credit [ITC], accelerated depreciation, rebates, state property tax exemptions). It does not include revenue impacts from the sale of renewable energy certificates, emission set-side programs, or other similar programs.

Although cost-competitiveness can vary depending on wind speed (also called “wind class”), the United States has many excellent wind sites where new installations can be developed cost-effectively. However, good wind sites are often located in remote areas where the transmission system is weak, requiring system upgrades and line extensions to transport power to load centers. This additional cost can adversely affect project economics and is currently a key focus of policymakers. Other challenges include the intermittent nature of wind and output variability (i.e., electricity is generated only when the wind blows) and the periodic lapsing and reinstatement of a key federal incentive, the production tax credit (PTC). The PTC, currently set at 1.9¢/kilowatt-hour (kWh) for 10 years of output and available through December 31, 2007, has helped close the economic gap of cost-effectiveness for many installations.

At the state level, incentives focus on property tax or sales tax credits and exemptions rather than on support for demonstration programs or for developing new technologies. Wind energy technology has also benefited from state renewable portfolio standards (RPS) that require a certain percentage of new generation to come from renewable resources. Because wind is one of the lowest-cost renewable options available to utilities and electricity suppliers, it has been used to meet a large portion of RPS renewable energy requirements and is expected to play a major role in the future.

Solar Photovoltaics (PV)

PV technology, which directly converts sunlight to electricity in a solid-state device, is also a fairly mature technology with more than 25 years of proven field performance. Compared to wind power, PV output is more predictable and is often coincident with utility load profiles (e.g., PV output is often highest on hot, sunny days, when demand for power is also highest). Thus, PV can provide peak electric load reduction, which may have a higher value than base load demand. Price reductions for PV systems have historically been 4% to 5% per year on average, and this trend is expected to continue (Navigant 2004a). PV is also one of the few renewable energy technologies that can be customer-sited; therefore, the technology can compete with retail electric rates as opposed to the lower wholesale rates with which centralized systems compete.

Nevertheless, electricity from PV is at least two to three times more expensive than U.S. retail electricity rates because the first cost of PV installation is relatively high. To address the first-cost issue, most state support for PV focuses on buy-down programs or rebates that help lower the high, up-front capital cost. In many states, buy-downs will be slowly phased out as PV systems become more economically viable and as the technology becomes self-sustaining in the marketplace. In addition to buy-downs, some states offer property and sales tax credits for PV, as well as grants to support industry infrastructure development (e.g., installer networks).

Solar Thermal

Solar thermal electric plants convert sunlight into electricity by concentrating sunlight onto working fluids, heating them to high temperatures. The fluids are then used to run conventional turbine-generators or heat engines. Plants potentially have high coincidence between peak output and peak demand, and large plants can take advantage of thermal storage to stabilize output and increase operating flexibility.

Larger central station options include parabolic troughs and power towers. Parabolic troughs use a heat transfer fluid that is heated as it circulates through the receivers and returns to a series of heat exchangers at a central location where the fluid is used to generate high-pressure superheated steam. The steam is then fed to a conventional steam turbine/generator to produce electricity. Power towers use fields of “mirrors” (or heliostats) to concentrate sunlight onto a central receiver tower; the energy can be concentrated as much as 1,500 times that of the energy coming in from the sun.

A smaller distributed power option is the dish Stirling engine/turbine, which involves a parabolic-shaped solar concentrator that reflects solar radiation onto a receiver. The collected heat is used directly by a heat engine to generate electricity.

Of these three solar thermal options, states have had the greatest field experience with parabolic troughs (e.g., 350 megawatts [MW] is currently operating in California). The key challenge today is the high capital cost. Solar thermal plant technology is currently not competitive with conventional power options and therefore state support is typically provided in the form of buy-downs or rebates. Some states also have solar set-asides within their RPS programs, which reserve a portion of the RPS target specifically for solar energy.

Solid Biomass

Broadly speaking, solid biomass is any form of organic matter, including wood, wood waste (e.g., sawdust, bark), agricultural residues (e.g., rice husks, wheat straw), construction and demolition debris, and animal waste (e.g., chicken litter). The single largest source of biomass today is the pulp and paper industry, which uses residues from papermaking to meet approximately 50% of its own energy needs.

Solid biomass technologies produce electricity by direct combustion or by combustion of gas derived from these fuels (i.e., co-firing). With direct combustion, biomass is burned in a boiler to produce high-pressure steam, which is then expanded through a steam turbine to generate electricity. Biomass co-firing with coal in existing coal plants is another potentially attractive option. To date, co-firing has been successfully demonstrated in a number of utility boilers, but only a few co-fired systems are in true commercial operation. Nevertheless, the technology is considered mature, and its deployment is likely to increase in those states that include it in their RPS.

The main advantages of solid biomass power are that it is a baseload resource and that it often converts a waste product into useful electricity and thermal energy. The main disadvantages are fuel price and availability, two issues not faced by other renewable energy options. Emissions and permitting are also more challenging for biomass than for other renewables. Some states support biomass applications through tax incentives and rebates. Direct combustion of solid biomass is also eligible in most state RPS programs.

Geothermal Power

Geothermal power converts heat from within the Earth's crust into electricity using well-proven and mature turbine-generator technology. The United States is currently the world leader in terms of total installed capacity. Unlike wind and solar technologies, geothermal is a baseload resource and can achieve very high annual capacity factors that improve overall economics. Geothermal power plants also have a small physical footprint and minimal environmental impacts. The best geothermal resources, however, are limited to a handful of Western states. In addition, finding good resources with good access to the transmission system can be an issue. Because of its more limited overall potential and mature economics, many state programs do not support the technology with direct financial incentives. Nevertheless, geothermal power is an eligible resource in a number of RPS programs, and untapped resources can be potentially developed. In the long term, a new technology called hot-dry rock could broaden the application of geothermal power.

Waste-to-Energy (WTE)

WTE facilities operate based on the same basic principle as solid biomass combustion facilities but use urban refuse (i.e., municipal solid waste) as fuel. WTE facilities, however, require boiler systems designed to handle a more heterogeneous, low-quality fuel, and the emissions control systems are designed to remove contaminants contained in municipal solid waste. WTE plants are also designed to recover noncombustible materials (e.g., glass, metals) either before or after combustion, depending on the plant design.

The key advantages of WTE technology are the steady supply of fuel and the benefits of waste reduction. The key challenges of WTE plants are high capital and operating costs, siting difficulties (mainly due to emissions issues), and the strong dependence on tipping fee revenue for favorable overall economics. States also have differing perspectives on whether WTE facilities qualify as "renewable" and if so, whether they can be used for RPS compliance. For both biomass and wastes, commercialization efforts are underway for next-generation technologies, such as biomass gasification and pyrolysis.[52] Successful commercial-scale demonstration programs are needed to provide market confidence in these technologies.

Landfill Gas (LFG) and Biogas

LFG and biogas are mixtures of approximately 50% to 60% methane and 40% to 50% carbon dioxide. They are the product of anaerobic digestion.[53] LFG is created as waste decomposes in the anaerobic environment of the landfill. For biogas derived from animal waste management and sewage, anaerobic digestion occurs in manmade digesters[54] as part of the overall process of treating these wastes.

The main advantages of biogas and LFG technologies are that they provide a steady supply of renewable fuels, make use of a low- or zero-cost feedstock, and involve moderate capital costs. As such, the economics are often favorable, even without incentives. These technologies also make use of mature power generation technologies (e.g., internal combustion engines, gas turbines, and boilers/steam turbines). LFG and biogas have also been successfully demonstrated with microturbines and fuel cells. Using biogas and LFG to produce electricity provides many environmental and economic benefits. Anaerobic digester systems for animal waste reduce odors and pathogens, improve water quality, reduce methane emissions, and improve farm revenues through energy self-sufficiency and the ability to use or sell the dried solid residues as fertilizer or animal bedding. Combusting LFG will reduce landfill odor (EPA 2005), methane emissions (landfills are the largest anthropogenic source of methane), and toxic organic compounds.

The main disadvantages of LFG and biogas applications are the relatively small scale of the applications and air permitting issues. Compared with other renewable energy options, the total market potential is relatively small. Some states directly support LFG and biogas with grants and incentives, and LFG and biogas are eligible resources within most state RPS programs.

Combined Heat and Power (CHP)

CHP, also known as cogeneration, is an efficient, clean, and reliable approach to generating simultaneous power and thermal energy from a single fuel source. CHP is not a specific technology but an efficient application of technologies to meet an energy user's needs. CHP uses waste heat from electricity generation to produce useful thermal energy for process heat and space heating or cooling for commercial and industrial facilities. A CHP system is substantially more efficient than purchasing electricity from the grid and generating thermal energy with a boiler or process heater.

A CHP system consists of a number of individual components—a prime mover (heat engine), a generator, heat recovery, and electrical interconnection—configured into an integrated system. The type of equipment that drives the overall system (i.e., the prime mover) typically identifies the CHP system. Prime movers for CHP systems include reciprocating engines, combustion or gas turbines, steam turbines, microturbines, and fuel cells. These prime movers are capable of burning a variety of fuels (e.g., natural gas, coal, oil, and alternative fuels) to produce shaft power or mechanical energy. Although mechanical energy from the prime mover is most often used to drive a generator to produce electricity, it can also be used to drive rotating equipment such as compressors, pumps, and fans. Thermal energy from the system can be used in direct process applications or indirectly to produce steam, hot water, process heat for drying, or chilled water for process cooling.

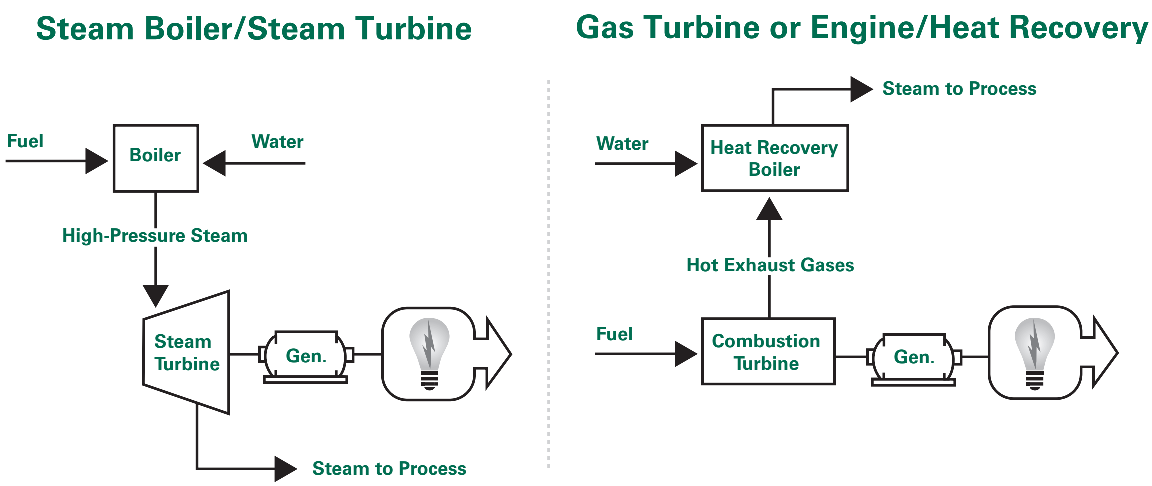
Figure C.1 shows two common configurations for CHP systems: (1) steam boiler/steam turbine, and (2) gas turbine or engine/heat recovery. Historically, the steam boiler/turbine approach has been the most

52 Pyrolysis is the rapid heating and cooling of biomass in the absence of air. It results in a complex liquid hydrocarbon mixture (pyrolysis oils) somewhat similar to crude oil, gaseous compounds such as hydrogen, methane, and carbon (i.e., char).

53 Anaerobic digestion is the conversion of organic material to biogas by microorganisms in the absence of oxygen.

54 With animal waste and wastewater, digesters (typically enclosed concrete structures) are required to contain the organic material and serve as a home for the microorganisms. In comparison, with LFG the biogas is produced naturally in the landfill over a period of years as the organic material slowly decomposes.

Figure C.1: Typical CHP Configurations



Source: EPA 2004.

widely used CHP system. In this approach, a boiler makes high-pressure steam that is fed to a turbine to produce electricity. The turbine is designed so that steam is left over to feed an industrial or other thermal process. Thus, one fuel input to the boiler supplies both electric and thermal energy by recovering waste heat from the steam turbine electric generator. This type of system typically generates about five times as much thermal energy as electric energy. Steam boiler/turbine systems are widely used in the paper, chemical, and refining industries, especially when waste or byproduct fuel exists that can be used to fuel the boiler.

Another common CHP configuration involves a combustion turbine or reciprocating engine to generate electricity. In these applications, thermal energy is recovered from the exhaust stream to make steam or to supply other thermal uses. These CHP systems can use very large (i.e., hundreds of MW) gas turbines, very small (i.e., tens of kilowatts [kW]) microturbines, engines, or fuel cell systems. In these systems, the thermal energy is typically one to two times the electric energy.

Clean Energy Markets

This section describes the current market for renewable energy technologies and CHP, including the growing competitiveness of renewable energy technologies and the proven track record of CHP applications in delivering cost-competitive energy. This clean energy market growth is leading to a range of local economic, environmental, and energy security benefits.

Renewable Energy Technologies

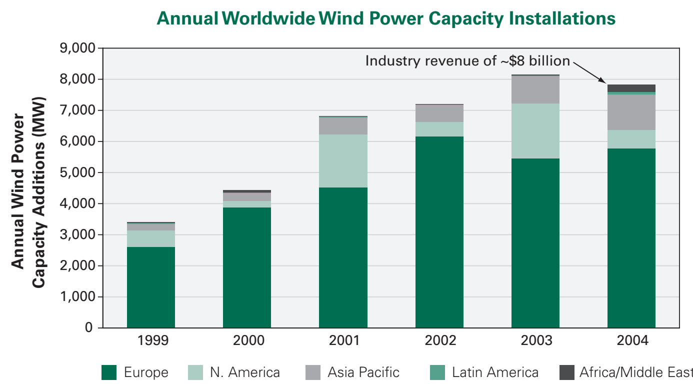
Renewable energy technologies are increasingly cost competitive and are becoming more established in the marketplace. As the opportunities and market have grown, especially over the last five years, large corporations have become major players in the renewable energy industry, bringing additional investment capital, expertise, and capabilities that have spurred further market growth. At the same time, both governments and consumers are placing value on the attributes associated with renewable energy. Many consumers have demonstrated a willingness to pay a premium for renewable energy, and many are able to enroll in voluntary green power programs.

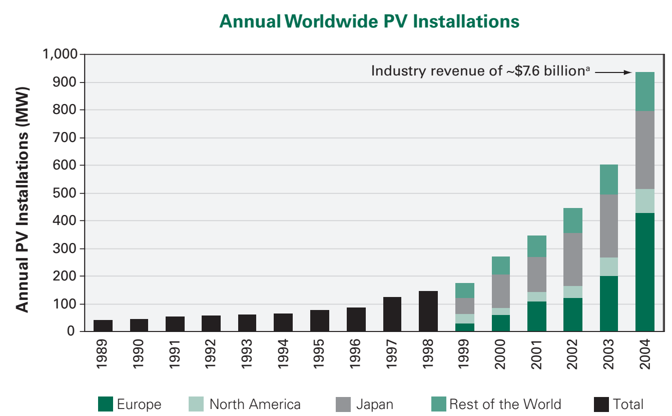
Governments are using incentives and other policy tools, such as RPS, to increase the amount of renewable energy produced. Renewable energy certificates (RECs), also called green tags, green certificates, and tradable renewable certificates, have emerged as the "currency" to both monetize and transact (i.e., trade and sell) the value of the attributes provided by electricity generated with renewable energy. The emergence of both "compliance" (e.g., RPS) and "voluntary" (e.g., green power) markets for renewable energy and renewable energy attributes, facilitated by the emergence of RECs, has changed the renewable energy marketplace and set the stage for future growth.

Both the wind and solar PV markets have experienced double-digit growth over the past decade, primarily as result of the increased demand for renewable energy. Globally, PV has had a 40% compounded annual growth rate (CAGR) since 1999. In 2004, the market was valued at approximately $7.6 billion per year from equipment sales and installation. The wind industry has undergone similar growth. Wind energy installations worldwide have experienced a 24% CAGR since 1999 (see Figure C.2) (Navigant 2005b).

In the United States, annual installations of renewable energy (excluding large-scale hydroelectric plants) have been between 600 MW and 1,700 MW per year between 2001 and 2003 (EIA 2004b). (Fluctuations during this period are primarily the result of changing government incentives.) As shown in Figure C.3, renewable energy (excluding large-scale hydroelectric plants) accounted for 2.2% of electricity consumption in 2003 (EIA 2004a, EIA 2004c). Today, hydropower and biomass, including WTE and LFG, dominate the renewable energy market in the United States. Annual installations of renewable energy (excluding large-scale hydro) in the United States are expected to reach more than 4,500 MW per year by 2015 in a business-as-usual scenario, resulting in an $8 billion market annually from equipment (Navigant 2005b).

Figure C.2: Annual Worldwide Installations for Wind Power and PV

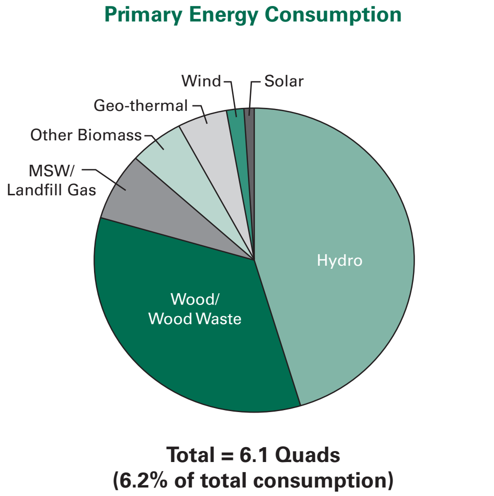


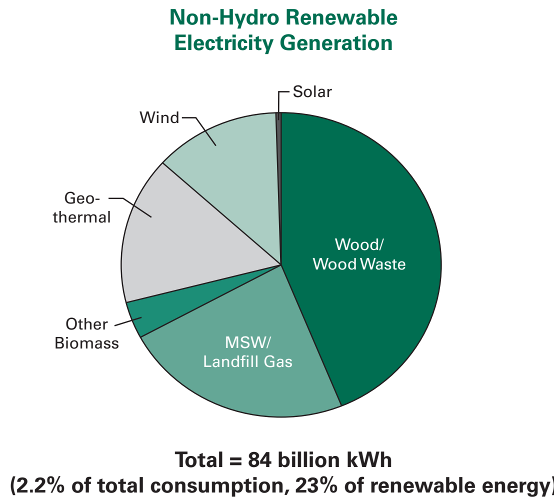


a Based on the total installed cost of systems.

Source: Navigant 2005b.

Figure C.3: U.S. Renewable Energy Snapshot *(2003 Data)*





Sources: EIA 2004a, EIA 2004c.

Combined Heat and Power (CHP)

Interest in CHP technologies has been growing among energy customers, regulators, legislators, and developers for a variety of reasons, including electric industry deregulation, environmental concerns, and unease over energy security. The growth of CHP has been fairly constant (with a slightly slower growth rate in the past few years) since the implementation of the Public Utilities Regulatory Policy Act (PURPA) in 1978, which created various incentives for CHP. PURPA has become somewhat less important in states with restructured electric markets but still provides some important support for CHP in regulated states. The U.S. CHP inventory in 2004 was 80.9 gigawatts (GW) at 2,845 sites. As shown in Figure C.4, almost 90% of this capacity is in the industrial sector, with about one-third of the total capacity in the chemical industry alone. The refining and paper industries make up another 25% of the total.

With recent increases in the price of natural gas and uncertainty in future prices, interest in CHP projects fueled by waste and opportunity fuels, such as landfill and digester gas, refinery gas, and wood waste, is growing.

Market Challenges Affecting Clean Energy Technologies

Because of their improving economics and performance, renewable energy technologies are becoming increasingly viable alternatives to conventional power generation technologies. Nevertheless, renewable technologies continue to face persistent market challenges that impede their growth and acceptance. Similarly, while CHP utilizes commercially proven technologies with higher efficiencies that can make it economically attractive, a variety of market, institutional, and regulatory barriers can slow its growth.

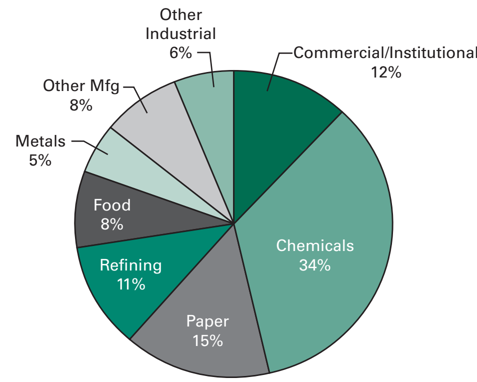
Renewable Energy

Key market challenges faced by renewable energy technologies include:

- High first costs compared with competing technologies.
- Grid integration issues related to the interconnection of distributed technologies and connecting resources in remote locations.
- A lack of maturity of other needed "infrastructure," such as sales, installation, and service.
- A need for more consumer education about the benefits of renewable energy.
- The lack of maturity and liquidity in emerging REC markets.
- Public concerns over aesthetics, noise, and environmental impacts related to certain technologies.

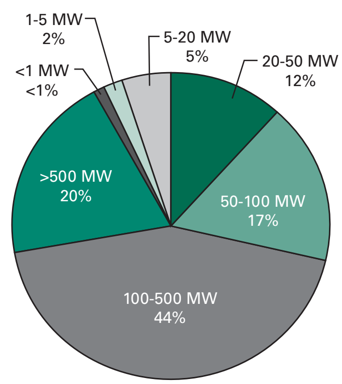
Recognizing the benefits of renewable energy to their constituents, many states are implementing a range of programs, including RPS, net metering, and public benefits funds, to address these challenges. For example, Pennsylvania is advancing renewable energy through its Energy Harvest Grant Program and Alternative Energy Portfolio Standard.

Figure C.4: U.S. CHP Capacity *(2004)*



Source: EEA 2004.

Figure C.5: Size Distribution of U.S. CHP Projects *(2004)*



Source: EEA 2004.

Combined Heat and Power (CHP)

Key market challenges faced by CHP include:

- CHP systems entail larger up-front capital investment, more complicated operation and maintenance (O&M) procedures, and higher O&M costs than conventional generation systems. These issues can be especially difficult for small to medium CHP users (i.e., less than 5 MW), who are less able to bear the additional cost and risk of onsite generation, regardless of the efficiency and environmental benefits.
- Rate-setting and regulation of interconnection are critical factors in the success of CHP. Uneconomical partial-load rates, such as standby or buy-back rates, exit fees, and interconnection requirements, can limit CHP's economic viability.
- Utilities can reduce the economic attractiveness of CHP projects by offering special low electric rates to the potential energy user that reduce the economic benefits of CHP.
- Although CHP typically provides an overall environmental benefit, it can increase the onsite emissions at the CHP facility. While this increase is typically offset by a greater decrease at another location (e.g., the power generator), most environmental regulations are not designed to recognize this benefit.

These potentially higher capital and operating costs and structural barriers are offset by the benefits of lower energy costs and increased power reliability where new CHP projects are being constructed. In addition, state policies (such as output-based regulations, interconnection standards, and public benefits funds) that reduce institutional, regulatory, and structural barriers to CHP and recognize its economic and environmental benefits are important components in addressing these challenges. For example, Connecticut has created an output-based regulation for small distributed generators for several pollutants, and has included CHP as an eligible resource for the state RPS.

Emerging and Innovative Clean Energy Supply Policies

State governments are crafting policies to reduce market and institutional barriers for clean energy technologies and accelerate their adoption in the marketplace. The *Guide to Action* focuses on established policies that have proven to be successful in various states. The following table describes emerging and innovative clean energy supply policies not covered in the *Guide to Action* and provides sources of additional information about these policies.

Table C.2: Emerging and Innovative Clean Energy Supply Policies

Policy	Description	For More Information
Contractor and Equipment Certification	Some states require equipment and contractor certification for renewable energy installations that receive buy-downs or state financial incentives. These standards ensure that high-quality products and services are provided to customers.	The North American Board of Certified Energy Practitioners (NABCEP) works with the renewable energy and energy efficiency industries, professionals, and stakeholders to develop and implement quality credentialing and certification programs for practitioners. http://www.nabcep.org/ In New York, NYSERDA's PV or Solar Electric Incentive Program provides cash incentives for the installation of small PV or solar-electric systems. The cash incentives are only available for PV systems purchased through an eligible installer. http://www.powernaturally.org/Programs/Solar/incentives.asp?i=1
Emissions Disclosure/Generation Disclosure	Similar to the nutritional dietary information found on most food packages, this policy would include a chart in every monthly bill that describes the sources of electricity generation and their emissions.	More than 20 states have some form of electricity label. Information on the Massachusetts program can be found at: http://www.mass.gov/dte/restruct/competition/info_disclosure_2001.htm
Content Requirements for Certain Electricity Contracts (Wholesale)	When a state enters into new contracts for purchasing power or is in the position to approve long-term contracts, the state can require that a certain percentage of the electricity generated is from renewable energy sources or meets thresholds for energy efficiency.	NY Executive Order 111 requires state agencies to purchase 10% of their electricity from renewable sources in 2005 and 20% by 2010. http://www.gorr.state.ny.us/gorr/EO111_fulltext.htm
Loading Order	A Public Utility Commission (PUC) can specify a certain sequence of technologies and resources that would be considered for meeting new electricity demand. Any deviation from this loading order would require utilities to explain the reason for this deviation to the PUC. This policy may need to be combined with others (such as simplified air emissions credits for energy efficiency, renewable energy, and distributed generation) in order to make it profitable or economical to utilities.	California's Energy Action Plan requires utilities to prioritize their resource procurements by following an established "loading order." http://irecusa.org/articles/static/1/1102615783_1018302029.html http://www.energy.ca.gov/energy_action_plan/index.html http://www.cpuc.ca.gov/static/energy/electric/energy+action+plan/
Standard REC Trading/Tracking Systems	A few state renewable energy programs currently have Web-based tracking systems for DG and/or assigning RECs based on this generation. These systems enable DG systems to participate in REC markets.	New Jersey established a separate REC trading system for solar PV. http://www.njcep.com/srec/

(continued on next page)

Table C.2: Emerging and Innovative Clean Energy Supply Policies (*continued*)

Policy	Description	For More Information
Mandated Long-Term Contracts for Renewables	This policy allows utilities in deregulated markets to sign long-term contracts with renewable energy generators. This would provide generators with the long-term certainty they need to obtain project financing.	The Colorado referendum that created the state's RPS requires a 20-year purchase for projects eligible to satisfy the RPS. http://www.dora.state.co.us/puc/rulemaking/Amendment37.htm A legislative act in Connecticut requires distribution companies to sign long-term Power Purchase Agreements for clean energy for no less than 10 years at a wholesale market price plus up to $0.055 per kWh for the REC. http://www.ctcleanenergy.com/investment/MarketSupplyInitiative.html
Builder/Building Incentives	Utilities and states can provide incentives for the construction and operation of energy-efficient and renewable energy homes and buildings (e.g., quicker and less expensive permits for homes with solar power).	Duke Energy lowered electric rates for ENERGY STAR-qualified homes. http://www.dukepower.com/ http://www.dukepower.com/news/releases/2005/feb/2005022201.asp New Jersey offers Solar PV rebates (ranging from $3.06/watt to $5.30/watt) to residential, commercial, and industrial applicants. http://www.njcep.com/html/2_incent.html
Utility Procurement Programs for DG	The PUC can require utilities to purchase or promote the installation of DG to meet increasing electricity demands. Renewable energy DG could be given preferential treatment in this program to promote reductions in carbon emissions. This would be similar to RPS.	The California Public Utilities Commission (CPUC) requires utilities to consider DG (customer- or utility-owned) as an alternative to distribution investments. http://www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/24136.htm
Integrating PUC goals into PBF Program Design (i.e., "Cross Walking")	This policy encourages the use of public benefits funds (PBFs) not only to support energy efficiency and renewable energy, but to help PUCs and utilities reach their goals (e.g., increased reliability, congestion relief, and permanent peak reduction).	New England Demand Response Initiative http://nedri.raabassociates.org/index.asp In Massachusetts, annual peak demand reductions from energy efficiency and PBF-funded load management ranged from 98 MW to 135 MW in 1998, 1999, and 2000. Cumulative reductions from these programs reached 700 MW (7.2% of peak) as of 2000. http://eetd.lbl.gov/EA/EMP/reports/PUB5482.pdf
Transparent Distribution Planning	Currently, the electricity distribution company primarily conducts distribution planning without outside feedback that could lead to lower-cost alternative solutions or taking into account other decisionmaking criteria. A transparent distribution planning process could allow customers and developers to align their investments with the greatest system need. In addition, the utility would benefit from customer response to the system need.	The California Energy Commission (CEC) is working with CPUC to create a transparent distribution planning process. http://www.energy.ca.gov/energypolicy/index.html

Source: Compiled by EPA based on multiple sources.

References

Title/Description	URL Address
AWEA. 2006. American Wind Energy Association (AWEA) news release: U.S. Wind Industry Ends Most Productive Year, Sustained Growth Expected for At Least Next Two Years. January 24.	http://www.awea.org/news/US_Wind_Industry_Ends_Most_Productive_Year_012406.html
EEA. 2004. Combined Heat and Power Installation Database. Energy and Environmental Analysis, Inc.	http://www.eea-inc.com/chpdata/index.html
EIA. 2004a. Electric Power Annual 2003. Energy Information Administration. December.	http://tonto.eia.doe.gov/FTPROOT/electricity/034803.pdf
EIA. 2004b. Existing Generating Units in the United States by State, Company and Plant, 2003. January 1.	http://www.eia.doe.gov/cneaf/electricity/page/capacity/existingunits2003.xls
EIA. 2004c. Renewable Energy Annual 2003. Energy Information Administration. 2004.	http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/rea_sum.html
EIA. 2004d. Renewable Energy Trends 2003. Energy Information Administration. July.	http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/trends.pdf
EPA. 2004. Output-based Regulations: A Handbook for Air Regulators. Office of Atmospheric Programs, Climate Protection Partnerships Division. April 22.	http://www.epa.gov/chp/pdf/output_rpt.pdf
EPA. 2005. U.S. Environmental Protection Agency Landfill Methane Outreach Program Web Site. Benefits of LFG Energy. 2005.	http://www.epa.gov/lmop/benefits.htm
Kiser, J. and M. Zannes. 2004. The 2004 IWSA Directory of Waste-to-Energy Plants. The Integrated Waste Services Association.	http://www.wte.org/2004_Directory/IWSA_2004_Directory.html
Lund. 2004. John Lund, 100 Years of Renewable Electricity, Renewable Energy World, July–August 2004.	http://www.earthscan.co.uk/defaultREW.asp?sp=&v=3
Navigant. 2004a. Navigant Consulting, Inc. interviews with PV manufacturers in 2004.	N.A.
Navigant. 2005b. Navigant Consulting, Inc. estimates based on industry interviews. August.	N.A.